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UPPER GUNNISON-UNCOMPAHGRE BASIN

PHASE 1 - FEASIBILITY STUDY

FINAL REPORT

Prepared
For

THE COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

By
HDR Engineering, Inc.
May 1989

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
RESOURCE ROOM PROPERTY

PREAMBLE

As graphically depicted on the cover, the water of the Upper Gunnison and Uncompahgre River Basins can be used to meet a variety of different and sometimes competing demands. These include recreational uses, irrigated agriculture, livestock production, and municipal and industrial uses. The basin is also confronted with the prospect of potential transmountain diversions.

This preliminary evaluation of the area's water resources was conducted in response to and in association with a large number of local, state, and Federal water interests. We are pleased to provide this report as the initial step in the identification, analysis, and financing of a balanced water management plan for the basin. We are confident that the data it contains will result in a more focused and informed discussion of the basin's complex water resource issues.

Colorado Water Resources and
Power Development Authority

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
RESOURCE ROOM PROPERTY

FINAL REPORT
UPPER GUNNISON-UNCOMPAHGRE BASIN
PHASE 1 FEASIBILITY STUDY

VOLUME I

Submitted to:

Colorado Water Resources and Power Development Authority
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Denver, Colorado 80203

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In association with:

WBLA Inc.
U.S. Bureau of Reclamation
Woodward Clyde Consultants
C.U. Center for Economic Analysis

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May 31, 1989

Mr. Uli Kappus, P.E., Executive Director
Colorado Water Resources and
Power Development Authority
1580 Logan Street, Suite 620
Denver, CO 80203

Re: Final Report for the Upper
Gunnison-Uncompahgre Basin
Phase 1 Feasibility Study

Dear Mr. Kappus:

H D R

We are pleased to submit this Final Report as required by our contract dated June 5, 1987. Five interim Task Memoranda have been submitted previously, each reporting in detail on certain aspects of the study. A Summary Report which discusses the study in a more concise manner is submitted under separate cover.

The objective of this study was to identify and evaluate water resource management plans to enhance the water-based economy of the Study Area in an environmentally sound manner. Both structural and non-structural components have been examined, evaluated and utilized to formulate alternative plans which would meet in-basin needs. A recommended plan has been identified which meets the study objective.

Non-structural measures related to the municipal and industrial sector were found to have little potential for saving water in the context of this basin-wide study because the total consumptive use in this sector is less than two percent of the total consumptive use in the entire Study Area at present. Some of the measures identified should be considered for implementation at the local level in the future, however. Non-structural measures identified in the agricultural sector were determined to be either technically or economically infeasible except for water rights exchanges and/or transfers and drought leasing.

Six alternative development plans were evaluated as a means of meeting future water demands and enhancing water-based recreation in the Study Area. The preferred plan consists of the following: a 20,000 acre-foot multipurpose reservoir in the Ohio Creek basin; a 25,000 acre-foot multipurpose storage reservoir in the Tomichi Creek basin; and ten recreation enhancement components. The total capital cost of this plan is approximately $55 million (January 1989 price level).

The plan could be developed in stages. A financial analysis was performed on an initial stage which includes one storage reservoir and the ten recreation components. The total capital cost of Stage 1 would be approximately $32 million based on the Tomichi Creek Reservoir. The analysis showed that the total annual cost associated with Stage 1 would be about $1.25 million. The annual income from the project is estimated to be about $140,000 but the project would result in significant economic benefits to the Study Area through increased tourism (estimated to be about $4.45 million). Construction of Stage 1 will also result in year-round increased streamflows which would result in fish and wildlife benefits. Although the recommended plan is not financially feasible based solely on direct project income, its benefit-cost ratio is attractive when all project benefits are included. Therefore, several methods of generating income in addition to direct project income were investigated as a means of meeting annual project costs. These methods included the following: formation of a special recreation district with taxing powers; use of authorized, but as yet unappropriated Aspinall Unit mitigation funds; and the lease or sale of land adjacent to and in the vicinity of the proposed reservoirs. It was concluded that, if implemented, these methods could provide sufficient income to repay the annual debt service of the recommended plan.

The study also evaluated potential pumped-storage hydroelectric and transmountain diversion projects which, when combined with the preferred in-basin development plan, would result in a more comprehensive project. This was evaluated because it was thought that a more comprehensive development plan might be more financially attractive than an in-basin plan by itself provided that benefits and costs could be equitably shared between the project participants.

The study effort showed that numerous potential pumped-storage hydroelectric sites exist in the Study Area and that several of these sites appear to be economically attractive. These projects may adversely affect existing reservoirs that are included in the project and future studies, if conducted, should evaluate these potential impacts.

Transmountain diversion projects that would divert water from the headwaters of the Taylor River and from Blue Mesa Reservoir were investigated. There are significant institutional and environmental considerations involved with potential out-of-basin diversions. These may include: perfecting water rights, changing existing water rights or exchange agreements, changing operations of existing facilities, and a wide array of environmental issues. There may also be other potential constraints identified if the study proceeds into a more detailed phase. For purposes of analysis, preliminary evaluations were made of alternative export plans which might yield

up to 100,000 acre-feet of water annually. These export plans were analyzed without drawing conclusions regarding the issue of the legal availability of water. The estimated cost of implementing the alternatives studied are within the range of water development costs currently being experienced by municipal and industrial users along the front range.

We wish to express our appreciation for having had the opportunity to perform this study and also for the excellent support and guidance we received from Mr. Blaine Dwyer, the Authority's Project Manager. We also wish to acknowledge the valuable input and insights we received from the Technical Steering Committee and the Advisory Committee throughout the course of the study. We look forward to future opportunities to be of service to the Authority.

Very truly yours,

HDR ENGINEERING, INC.

Andrew Tczap, P.E.
Project Manager

AT:jb

Enclosure

UPPER GUNNISON-UNCOMPAHGRE BASIN STUDY

FINAL REPORT

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VOLUME II

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1.0 INTRODUCTION

This preliminary evaluation of alternative water management plans for the Upper Gunnison and Uncompahgre River basins was conducted by the Colorado Water Resources and Power Development Authority (Authority) at the request of the study sponsors: the Upper Gunnison River Water Conservancy District (UGRWCD) and the Colorado River Water Conservation District (CRWCD). In the introduction that follows, the project background is addressed, as are the study authorization, objectives, and process. Also discussed are the public involvement program and the organization of this report.

1.1 BACKGROUND AND PERSPECTIVE

The area investigated in this Study (the Study Area) is the Upper Gunnison Sub-basin (upstream of Crystal Dam) and the Uncompahgre Sub-basin, as shown in Figure 1.1. Located in west central Colorado, the Study Area is bordered by the Continental Divide to the east and southeast, the San Juan Mountains to the south, the town of Delta to the west, and the North Fork of the Gunnison and Roaring Fork watersheds to the north. The study area encompasses approximately 5120 square miles of land, which is approximately 13 percent of the entire area of Western Colorado (west of the Continental Divide).

For close to a century, agriculture has been the largest user of water within the Study Area. The Gunnison River Basin was controlled by the Ute Indians until a large tract was opened for settlement in 1873 and the remainder of the basin was ceded in 1881. The first settlers were miners, many of whom turned to farming and ranching as their means of livelihood when the mining industry declined after 1893. Agriculture soon established itself as the basic industry in the area. Irrigation was found necessary to mature crops, with the result that extensive agricultural water supply systems were developed in the ensuing years.

More recently, recreation has become the other predominant factor in the local economy. The Study Area offers diverse recreational opportunities throughout the four seasons of the year, with fishing the most popular activity in terms of visitor days.

Water resources planning in the Upper Gunnison Basin began in the early 1900's and resulted in the construction of the second project ever undertaken by the U.S. Bureau of Reclamation (USBR), the Uncompahgre Project. The major features of this project are the Gunnison Tunnel, Taylor Park Reservoir, and 792 miles of canals, laterals, and drains (USBR, 1982). The Gunnison Tunnel diverts water from the Upper Gunnison River for irrigation in the Uncompahgre Valley. Taylor Park Reservoir supplies water for irrigation, fisheries, and recreation; it also provides flood protection on the Taylor River.

Subsequent USBR development work in the Upper Gunnison Basin resulted in the construction of Blue Mesa Reservoir, the largest reservoir in Colorado. That project was followed by construction of Morrow Point and Crystal Reservoirs, located immediately downstream of Blue Mesa (USBR, 1956). Together, these reservoirs form the Wayne N. Aspinall Unit (formerly known as the Curecanti Unit) of the Colorado River Storage Project (CRSP). The Aspinall Unit has a total storage capacity of approximately 1,086,000 acre-feet (af) and an installed hydroelectric power capacity of 208 megawatts (MW).

Public Law 485, approved in 1956, authorized the Department of the Interior to construct the Colorado River Storage Project consisting of the Curecanti (now called Aspinall), Flaming Gorge, Navajo and Glen Canyon Units. The Act also authorized a number of smaller projects to be constructed if technical and economic feasibility were demonstrated and other specified conditions were met. These projects were termed Participating Projects in the Act. Two CRSP participating projects located in the Study Area have been constructed by the USBR: The Dallas Creek Project and the Bostwick Park Project. Another potential CRSP participating project, the Upper Gunnison Project, was studied in detail, and several potential reservoir sites and

water conveyance systems were identified (USBR, 1964). The Concluding Report for the Upper Gunnison Project (USBR, 1973) was published in 1973. None of the proposed facilities have been constructed to date.

1.2 STUDY AUTHORIZATION

In 1981 the Colorado General Assembly enacted Senate Bill 19, which created the Colorado Water Resources and Power Development Authority (Authority). The specific provisions of the Colorado Water Resources and Power Development Authority Act are documented in Title 37, Colorado Revised Statutes 1973, as amended, parts 37-95-101 through 37-95-114. The Authority, by law, is a political subdivision of the State and not an agency of State government. Members of the Authority's Board of Directors are appointed by the Governor with confirmation by the Senate. There are nine board members: one from each of the eight major drainage basins in Colorado, and a ninth representing the city and county of Denver.

The General Assembly created the Authority for the primary purpose of aiding in the planning, design, financing, and construction of water and hydroelectric power projects that will put Colorado's water supplies to beneficial use. To implement this, the Authority has been empowered, under the specific guidelines in the law, to issue revenue bonds for financing of such projects.

The Authority, at the request of the Upper Gunnison River Water Conservancy District and the Colorado River Water Conservation District, authorized the Phase I Feasibility Study for the Upper Gunnison-Uncomprahgre Basin. The Authority entered into a contract with HDR Engineering, Inc., on June 5, 1987 to carry out the study. Work on the study began according to schedule on June 8, 1987.

HDR assembled a team (the Study Team) consisting of in-house personnel plus the following subconsultants to perform speciality areas of the Study under HDR leadership:

Subconsultant	Function
CU Center for Economic Analysis (CUCEA), Boulder, Colorado	Project Demands
WBLA, Inc. Boulder, Colorado	Water Rights/ Hydrologic Modeling
Woodward Clyde Consultants (WCC) Denver, Colorado	Geotechnical Engineering
Dr. Robert Behnke, CSU	Aquatic Biology
Dr. Hugo Ferchau Western State College	Botany and Implementation Strategy
Robert Rosette Montrose, Colorado	Waterfowl and Stream Access

In addition, the Study has been performed with the aid of the USBR through their Technical Assistance to States Program. Their participation consisted of providing in-kind services and producing certain study products as an adjunct to the study team. The USBR's participation, although including some input to most of the study tasks, was concentrated in the areas of: hydrologic analysis; preparation of agricultural water demand forecasts; identification and evaluation of structural components; and preparation of environmental evaluations of components and plans. It has been the Authority's responsibility to promote coordination between HDR and the USBR as well as to make final decisions regarding the Study direction.

The Colorado Division of Wildlife participated in the study through a grant of funds by providing technical input, and by active participation on study committees.

1.3 STUDY OBJECTIVE

The objective of this Study is to identify and evaluate water resource management plans to enhance the water-based economy of the Study Area in an environmentally sound manner. Both structural and non-structural components have been examined. The purpose of the structural measures (such as dams, pipelines, and tunnels) is to develop additional water supplies consistent with the in-basin needs and the State's compact entitlements. The purpose of non-structural measures (such as enhanced water management through water exchange, reuse, and conservation) is to obtain greater environmental and economic benefits from the existing resource base.

One of the primary goals of this Study is to improve fisheries and recreational opportunities and to enhance public access to these activities. Other important goals are to provide for future agricultural, municipal, and industrial water demands and to provide additional flood protection within the Study Area.

Given the apparent inability of recreational and agricultural water users to pay for additional water development, other sources of revenue, including hydropower generation and potential out-of-basin water sales, were evaluated. This was done to identify very general options which, when combined with the preferred in-basin development plan, would result in a more comprehensive project with enhanced financial attractiveness. These options may require participation from electrical power entities or east slope water suppliers. This study has not speculated on the specific institutional relationships that might be involved. If these entities pursue a cooperative approach to project development, further study would be required to arrive at an equitable sharing of project costs and benefits.

More specifically, the Study objectives are as follows:

1. To identify in-basin opportunities for streamflow enhancement, such as low flow or late-season flow augmentation to improve existing fisheries;

2. To examine the physical and legal availability of water in the Study Area as well as future in-basin water demands (including water for streamflow enhancement);

3. To examine potential water and hydropower components in the Study Area;

4. To determine annual water yield, cost, and technical feasibility of both structural and non-structural alternatives available for development;

5. To make a preliminary assessment of the economic and financial feasibility of water development alternatives;

6. To examine the technical and financial feasibility of using hydropower and potential out-of-basin sale of water (that is, in excess of in-basin demands) to enhance the financial feasibility of in-basin water development components of the project; and

7. To select alternative in-basin water development plans for Phase II investigation.

The planning and design process for the entire project is carried out in phases, each phase culminating in a decision as to whether or not the particular component should continue on to the next phase. The present study consists of a Phase I Feasibility Study (prefeasibility) evaluation and is the first step in a complex process leading to construction of a water resource project. The steps in this process are illustrated in Figure 1.2 for a project which includes a storage reservoir. The Study has been conducted in sufficient detail to distinguish the major differences among alternative plans

and to assess, on a preliminary level, the viability of each alternative. Using the findings of this Study, critical aspects of the alternative plans can be selected for further investigation, including additional cycles of screening, public evaluation, and reformulation. Then, if the results warrant it, a more detailed study can be carried out to determine the economic and technical feasibility of the preferred plan(s).

Although delays arising from such factors as political controversy, financial obstacles, environmental considerations, or bureaucratic procedures are not entirely avoidable, the approach outlined above helps to streamline the process. It defers expensive detailed environmental evaluations, including certain requirements of the National Environmental Policy Act (NEPA) process, and design work until there is some degree of confidence that a component is technically, economically, and politically feasible. A key goal in this approach is to balance water resources development with environmental protection and recreational benefits.

1.4 STUDY PROCESS

This Phase I Feasibility Study is composed of 16 tasks, defined in Table 1.1 and shown as they interrelate in Figure 1.3. These tasks comprise more than 45 subtasks and cover the technical, public involvement, and management aspects of the Study.

The Study has been performed under the direction of the Authority, assisted by an Advisory Committee (AC) composed of 21 individuals representing a wide variety of interest groups, and by a Technical Steering Committee (TSC).

The TSC consists of representatives from the following organizations:

Colorado Division of Wildlife (CDOW)

Colorado River Water Conservation District (CRWCD)

Colorado Water Conservation Board (CWCB)

Tri-County Water Conservancy District (TCWCD)

Uncompahgre Valley Water Users Association (UVWUA)

United States Bureau of Reclamation (USBR)

Upper Gunnison Water Conservancy District (UGWCD)

The TSC's purpose has been to review the progress of the Study periodically and provide advice and recommendations to the Authority concerning the conduct of the Study.

The Advisory Committee is comprised of representatives from 21 organizations that, taken together, represent a broad range of interests relevant to the water resources of the Upper Gunnison and Uncompahgre sub-basins. The intent when forming this committee was to ensure that interested parties were aware of the study progress and interim results in time for the study team to incorporate their advice and concerns. The Advisory Committee members are listed in Table 1.2. The Advisory Committee members were sent a copy of each Task Memorandum. They were also notified when meetings were scheduled to discuss interim findings. Advisors were encouraged to offer questions and comments at these meetings. The dates and subjects of the meetings are listed in Table 1.3.

The Advisory Committee provided valuable direction throughout the course of the effort. Given the wide range of interests represented on the Advisory Committee, it is not reasonable to expect that a unanimous consensus be

obtained in an effort of this magnitude. However, the contribution of these individuals has resulted in a comprehensive evaluation of the conflicting interests and their efforts are gratefully acknowledged.

1.5 PUBLIC INVOLVEMENT

A public involvement program was established and implemented in conjunction with the Study in order to achieve the following objectives:

1. Inform the public about the Study process, purpose, and need;
2. Invite public comment during the Study process;
3. Establish and maintain credibility of the Study process.

The Authority has been responsible for conducting the public information and involvement program. HDR has provided information and other materials in support of the Authority's efforts, and has also attended and participated in meetings at the request of the Authority.

Interaction with the AC and the public has been the responsibility of the Authority's Project Manager. Several public meetings and AC meetings have been held in Montrose and Gunnison during the course of the Study. Dates and subjects of these meetings, all of which were open to the public, are shown in Table 1.3. In addition to these meetings, Authority representatives and Study Team members met with more than 20 individuals or representatives of economic, environmental, and governmental entities. Their input is also gratefully acknowledged.

In addition, data repositories were established where interested parties not serving on the TSC or AC could have access to all the reports prepared during the course of the Study. A list of the data repositories is in Table 1.4.

1.6 REPORT ORGANIZATION

The remaining 16 chapters of this report provide condensed documentation of the work performed in the course of this study, discusses the formulation and evaluation of plans as well as the implementation strategy, and also presents conclusions and recommendations. In addition, a glossary and a list of acronyms and abbreviations is included at the end of the report. The Appendices contain further information that may be useful as a source of more detail including a bibliography which includes the references cited in this report. No executive summary is included; a summary report has been prepared as a separate document.

TABLE 1.1

Task Breakdown

Task No.	Description
Tasks 1-4 and 6	Inventory and analyze natural resources, infrastructure, and socioeconomic structure of the Study Area; include a hydrologic assessment of water resources, a forecast of future demands, and an evaluation of existing physical facilities to meet future demands; aim at achieving an understanding of the present situation in the Study Area, assessing the total water resources available, and estimating future demands on the area's water resources.
Task 5	Identify existing recreational use, determine the potential for increased recreational use, formulate conceptual plans for new recreation facilities, and quantify the benefits to the Study Area resulting from the development of those new recreational facilities.
Tasks 7-10	Develop alternative plans, with both structural and non-structural components, to satisfy future demands and identify potential financing strategies for development.
Task 11	Identify environmental impacts associated with the preferred plan(s) and evaluate possible mitigation measures.
Task 12	Select preferred plan(s) and evaluate the financial feasibility of the plan(s).
Tasks 13-15	Manage Study activities.
Task 16 (optional)	Perform geotechnical field investigations if required to successfully complete other Study tasks.

TABLE 1.2

Advisory Committee Representatives

BUREAU OF LAND MANAGEMENT
Mr. Terry Reed

CITY OF AURORA
Mr. Tom Griswold

COLORADO DIVISION OF PARKS AND OUTDOOR RECREATION
Mr. Tom Kenyon

COLORADO DIVISION OF WILDLIFE
Ms. Rebecca Frank

COLORADO RIVER WATER CONSERVATION DISTRICT
Mr. Lee Spann

COLORADO WATER CONSERVATION BOARD
Mr. Bill McDonald
Mr. David Walker

COLORADO WILDLIFE FEDERATION
Mr. Ralph E. Clark, III

DELTA COUNTY
Mr. Charle V. Hallenbeck

UNCOMPAHGRE VALLEY WATER USERS ASSOCIATION
Mr. Jim Hokit

UPPER GUNNISON WATER CONSERVANCY DISTRICT
Mr. L. Richard Bratton

U.S. BUREAU OF RECLAMATION
Mr. Walt Fite

DISTRICT 10 REGIONAL PLANNING COMMISSION
Mr. David Anderson

GUNNISON COUNTY
Ms. Joanne Williams

HIGH COUNTRY CITIZENS ALLIANCE
Mr. Don Bachman

NATIONAL PARK SERVICE
Mr. Joe Alston

PROJECT 7 WATER AUTHORITY
Mr. Richard L. Margetts

STATE ENGINEER'S OFFICE
Mr. Thomas A. Kelly

TRI-COUNTY WATER CONSERVANCY DISTRICT
Mr. Art Cannon

TROUT UNLIMITED
Mr. Robert E. Wright, Jr.

U.S. FOREST SERVICE
Mr. Ray Evans

WESTERN COLORADO CONGRESS
Ms. Ann Longsworth

TABLE 1.3

Advisory Committee and Public Meetings

	Date	Meeting
1.	May 7, 1987	AC meeting on plan of Study; held in Montrose
2.	August 26, 1987	Public meeting to provide general overview of Study; held in Gunnison
3.	December 16, 1987	AC meeting to discuss Task Memorandum No. 1 and review progress to that date; held in Gunnison
4.	April 14, 1988	AC meeting to discuss Task Memoranda Nos. 3 and 4 and to review progress to that date; held in Montrose
5.	June 21, 1988	AC meeting to discuss Task Memorandum No. 5 and to review progress to date on Task Memorandum No. 6; held in Gunnison
6.	November 15, 1988	AC meeting to discuss results of Task Memorandum No. 6 prior to issuance of the draft; held in Gunnison
7.	December 15, 1988	Public meeting to present results of Task Memorandum No. 6 and to solicit input from the public and the Advisory Committee members in attendance
8.	April 24, 1989	Combined AC and Public meetings to discuss draft Final and Summary Reports; held in Gunnison

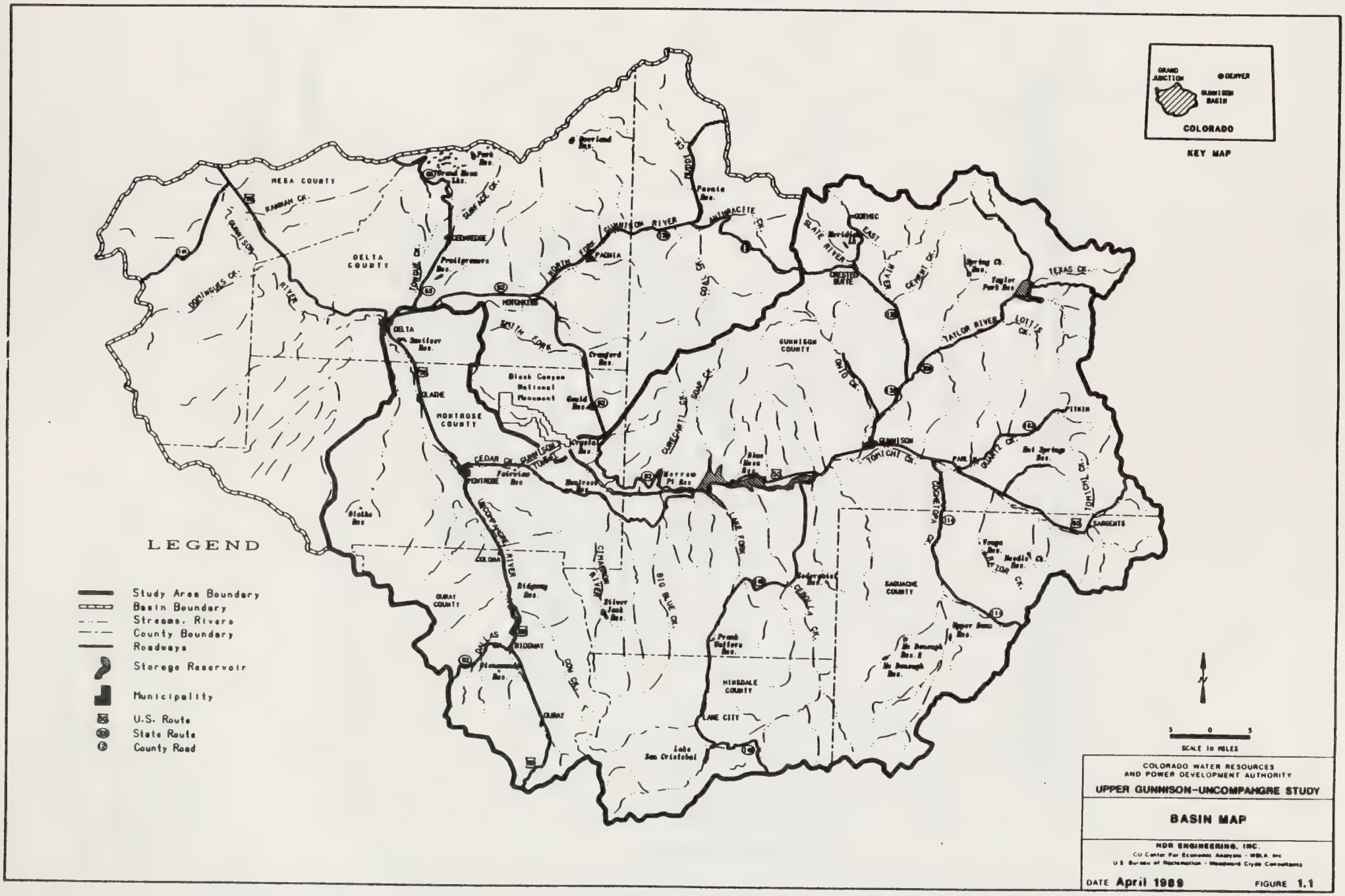
TABLE 1.4

Data Repositories

Bonnie Baril
Gunnison County Public Library
307 North Wisconsin
Gunnison, Colorado 81230

Zee Dee Kinkel
Montrose Library District
434 South First Street
Montrose, Colorado 81401

Nate Lund
Western State College
Savage Library
Documents Section
Gunnison, Colorado 81230



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

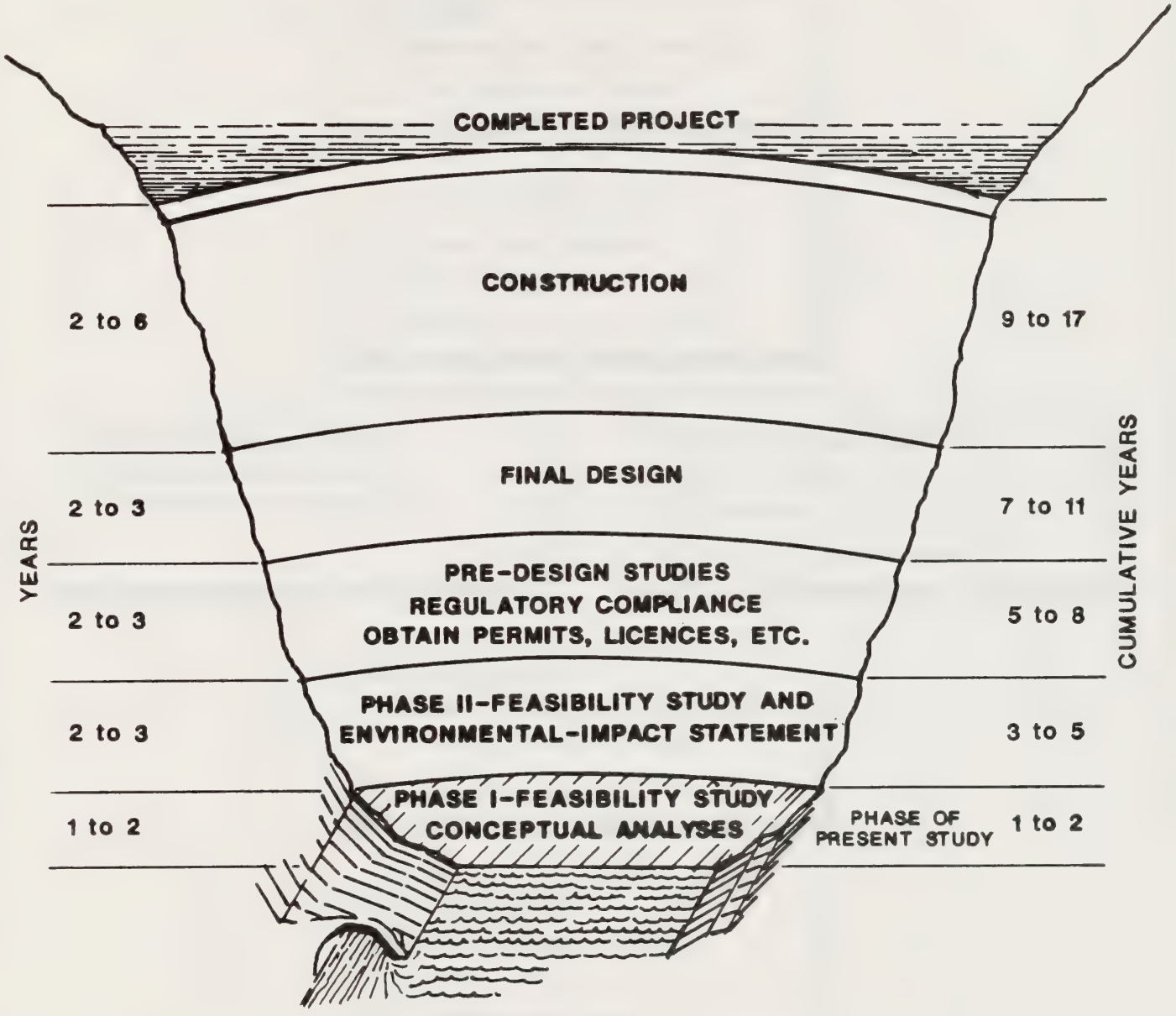
BASIN MAP

NDR ENGINEERING, INC.

CU Center For Economic Analysis - WBLA Inc

U.S. Bureau of Reclamation - Woodward Clyde Consultants

DATE April 1989 FIGURE 1.1



LEGEND

CURRENT STATUS
OF GUNNISON STUDY

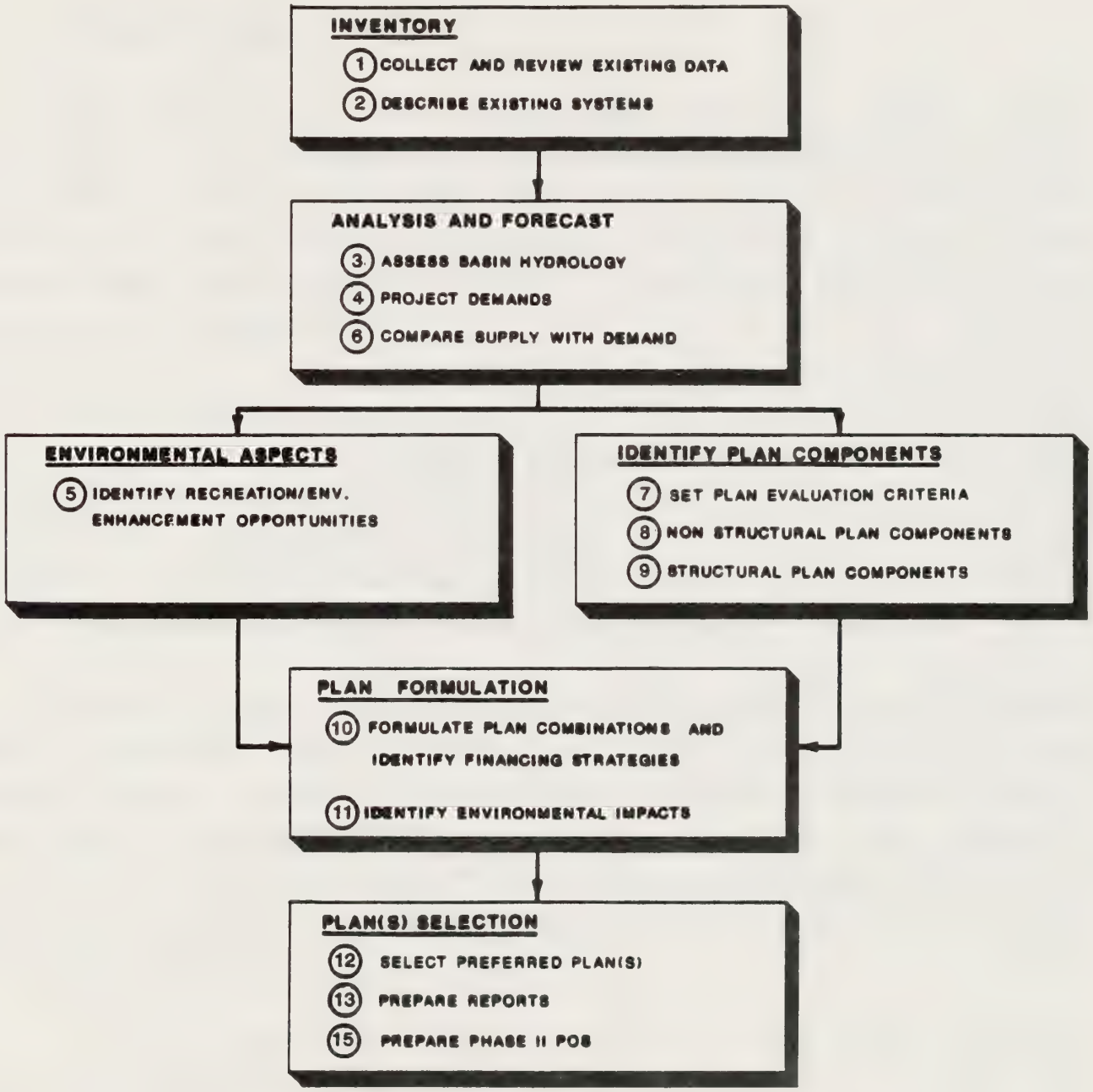
COLORADO WATER RESOURCES
AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

TIME REQUIRED TO IMPLEMENT A WATER DEVELOPMENT PROJECT

HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA, Inc.
U.S. Bureau of Reclamation • Woodward Clyde Consultants

DATE: April 1989 FIGURE: 1.2



NOTE:
Numbers in Circles Correspond to Plan of Study Task Numbers

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

BASIN STUDY PROCESS

HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA, Inc.
U.S. Bureau of Reclamation • Woodward Clyde Consultants

DATE: April 1989 FIGURE: 1.3

2.0 GENERAL DESCRIPTION OF THE BASIN

2.1 HISTORICAL OVERVIEW

The first explorations in the Basin were made by the Spanish. Many of the names of streams and mountains still bear the names given them by Captain Juan Marie de Rivera in 1765 and Father Escalante in 1776. In 1853 Captain Gunnison was commissioned by the government to search for a feasible railroad route across the Continental Divide. His party did much of the early exploration in the Basin.

The Ute Indians retained possession of the Gunnison River Basin until 1873 when they ceded to the Federal government a large tract of upper basin land, which was immediately opened for settlement. The lower basin was not settled until the compromise of 1881 between the U.S. Government and the Ute Indians. As a result of the compromise, the Indians agreed to leave the area and locate in the Uintah Reservation in the territory of Utah.

The lure of gold, silver and other minerals caused an influx of people and the population increased rapidly until 1893. With the decline of the mining industry, agriculture became the basic industry of the Basin. Many of the miners, disappointed in their search for gold and silver, turned to farming and ranching as a means of livelihood and by 1900 most of the readily available sources of irrigation water had been developed by private individuals and small irrigation companies.

In the late 1940's the relative abundance of automobiles and especially four-wheel drive vehicles resulted in a significant increase in tourists drawn to the area for outdoor recreation activities. That trend has continued to increase over the years and recreation is now a very important segment of the economy of the Study Area.

2.2 LOCATION AND TOPOGRAPHY

The Gunnison River Basin is located in West-Central Colorado. Its boundary encompasses an area of 8020 square miles and includes all or major portions of Gunnison, Montrose, Delta and Ouray Counties and portions of Mesa, Hinsdale, Saguache and San Juan Counties. It is approximately 145 miles long east to west and 95 miles wide at its widest point north to south. The Gunnison River and its tributaries drain about eight percent of the area of the State of Colorado.

The Gunnison River Basin ranges in elevation from approximately 4550 to 14,300 feet and has an extremely variable topography. The lower river basin has broad, nearly level to moderately sloping valleys, flanked by low rolling hills which break rather abruptly into moderately to steeply sloping mesas highly dissected by steep sided drainageways or canyons. Above the mesas on the northeast and south are steeply sloping dissected plateaus which extend to the headwaters of the major streams. The streams are shallow at this elevation and topography is characterized by gently to strongly sloping valleys. These valleys are interspersed with steeply sloping smooth rolling hills at the north boundary of the Basin and very steep rough glaciated peaks on the south boundary.

The upper portion of the Gunnison River Basin is typified by very high, glaciated peaks whose slopes descend into gently to strongly sloping high mountain basins and into long steep sided ridges. They are separated by strongly sloping, narrow valleys that become less steep and considerably wider at the confluence of major streams and at lower elevations.

2.3 CLIMATE

Climate in the Gunnison River Basin varies considerably but generally could be considered as semiarid. Variation is due largely to the wide range in elevations. Average annual precipitation varies from more than 40 inches in the upper reaches of the basin to less than 10 inches in the lower valleys.

Measured average annual snowfall varies from more than 460 inches at Ruby and 400 inches at Savage Basin, to approximately 170 inches at Crested Butte in Gunnison County and 20 inches at Grand Junction. Upper basin lands have an annual frost-free period of less than 70 days, while lower basin valleys near Grand Junction average around 190 days.

2.4 GEOLOGY

The bedrock of the Gunnison Basin can generally be divided into three rock types; (1) crystalline intrusive and metamorphic rocks, (2) sedimentary rocks, and (3) rocks of volcanic origin. The oldest rocks in the basin are 1.4 to 1.8 billion years old (Precambrian). They are crystalline intrusive or metamorphic rocks such as granite, gneiss, or schist. The rocks in the Black Canyon of the Gunnison are typical of Precambrian crystalline rocks in the region.

The sedimentary rocks of the basin were deposited during two eras of geologic history. The older sedimentary units include the Leadville Limestone which was deposited in a shallow ocean during the early Paleozoic Era (320 to 570 million years ago). The Maroon Formation, consisting of arkosic sandstone and conglomerate, was deposited alongside the ancestral Rocky Mountains which were uplifted about 320 million years ago.

The second era of sedimentary rock deposition was the Mesozoic, when the mountains had been eroded and the region was located at an elevation at or below sea level. These younger sedimentary rocks include thick sequences of sandstone, shale, coal, and some conglomerates. These rock units include the Mesaverde Formation, Dakota Sandstone, Mancos Shale and Morrison Formation. These rocks cover the western portion of the basin.

The structure of the rocks in the basin varied dramatically from east to west. In the eastern part of the basin the Precambrian and Paleozoic rocks have been uplifted and exposed by large normal faults and minor thrust faults. The sedimentary rocks, including the younger rocks, have been folded and faulted. In the western part of the basin the sedimentary rocks are

relatively flat lying or gently warped. Glaciation has strongly influenced the topography in the upper basins. Glaciers carved out the upper valleys forming the distinctive U-shaped valleys. In addition, glacial drift filled valleys and glacial meltwaters deposited sediments in lower elevations. Valley walls, over steepened by the glaciers, have moved toward the valleys leaving slopes of landslide debris which may extend for several miles.

2.5 LAND USE AND OWNERSHIP

Lands of the Gunnison River Basin are used primarily for the production of timber, range-forage, mountain meadow hay, and irrigated crops. There are approximately 264,000 acres of irrigated land within the basin. Approximately 170,000 acres are located within the study area. Fruits and truck crop farming together with general and cash-crop farming and the production of forage and grain crops for livestock feed are the principal types of agricultural cropping. The irrigated lands at higher elevations are limited by a short growing season to the production of legume-grass hay or pasture. Private and publicly owned non-irrigated land furnishes summer grazing for livestock.

About 72 percent of the land in the basin is publicly owned. The breakdown of land ownership in the basin is as follows:

Federal	71.4%
State	0.5%
Private	28.1%

2.6 WATER RESOURCES

The water supply for the Gunnison River originates principally from the melting of winter snowpack on the high mountain peaks, augmented by summer precipitation. There is considerable variation in watershed yield, reflecting climatological and meteorological differences in the different parts of the basin. Water yields range from more than 30 inches of runoff in parts of the

Anthracite Range, West Elk, and San Juan Mountains, to less than 1 inch in the lower, drier parts of the Basin. Even within the higher parts of the Basin, significant differences occur in the watershed yield. The average annual discharge of the Gunnison River at Grand Junction (USGS gage 09152500) is 1,898,000 acre-feet (af) for the 79-year period of record.

The dominant use of water within the Basin is for irrigation. The climatic regime is such that successful crop production requires irrigation. Since the streamflows are mainly derived from snow melting, they are quite variable. The peak flows characteristically occur in the late spring and early summer. Runoff during this period is generally in excess of immediate requirements throughout the basin.

The rate of streamflow diminishes during the late summer and in many instances becomes insufficient to meet the crop requirements for irrigation water. Shortages of late-season water are common on tributary streams in those areas which depend on direct diversion of natural streamflow for their irrigation supplies. These shortages limit the agricultural development and production in several parts of the basin.

2.7 RECREATION

The basin is outstanding in many respects in recreational attractions. Mountain scenery, together with fishing, hunting, skiing, camping, whitewater boating, and other recreational activities, have caused tourist trade to increase rapidly. A substantial portion of the income in certain sections of the basin is derived from tourist trade. The Gunnison River with its tributaries offers some of the finest stream fishing in the state, while Taylor and Blue Mesa Reservoirs are major attractions for the boat fisherman. The mountains around Ouray, nationally known as the Switzerland of America, offer incomparable scenery and wilderness for the photographer and nature lover. From its mining heritage of the past, the area has its share of famous mining camps, old ghost towns and abandoned railroad grades to intrigue the historian and amateur prospector. Large numbers of big game animals, chiefly

deer and elk, are found in the basin. Many productive fishing waters and areas of productive upland game habitat are also found within the basin.

2.8 DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS

The population of the Study Area in 1986 is estimated at approximately 44,000. Montrose is the largest incorporated city with a 1988 population of 9957. Population of the Study Area by county is as follows:

Study Area Population, 1986

County	Population
Gunnison	11,680
Saguache	250
Hinsdale	300
Montrose	23,240
Delta	6,910
Ouray	1,970
Total	44,350

The economy of the basin has historically been cyclic with boom and bust periods occurring as a result of mining and energy development activities. Less pronounced cycles have also occurred as a consequence of the national economic cycles. The key economic sectors in the basin are: agriculture, tourism and recreation, Federal government, state government, energy, food products manufacturing, and wood products manufacturing. The most important economic sectors in the Study Area based on share of total earnings are: tourism and recreation, Federal/state government, energy, and agriculture.

3.0 EXISTING WATER SUPPLY ENTITIES

3.1 INTRODUCTION

This section identifies and briefly describes the various water suppliers and users within the study area. The Colorado River Water Conservation District (CRWCD), while not a water supplier or user, is involved in water development within the study area and is a sponsor of this study. Therefore, a brief discussion of that entity and its interest in the study area is also presented in this chapter.

A more detailed description of water suppliers, their facilities and their operating practices is presented in Appendix B.

3.2 WATER SUPPLIERS AND USERS

For the purpose of discussion, water suppliers and users have been classified by the predominant purpose they serve. The following categories of water use have been established to describe the water suppliers and users in the Study Area: regulatory, hydroelectric, agricultural, and municipal and industrial (M&I). The term "regulatory" was coined to describe the Federal facilities constructed to regulate streamflow to meet Lower Colorado River Basin compact commitments during dry periods without curtailment of water use in the Upper Basin. Although the Aspinall Unit produces a significant amount of hydroelectric power, it is classified herein as a regulatory system because it was constructed primarily to regulate Gunnison River flow. The Aspinall Unit is owned and operated by the United States Bureau of Reclamation (USBR).

The only commercial hydroelectric system in the study area is the 700 kilowatt (kw) Ouray Hydroelectric Facility. The Rocky Mountain Biological Laboratory operates a microhydro station but it generates power for internal consumption only.

The primary entities supplying agricultural water in the study area are the Upper Gunnison River Water Conservancy District (UGRWCD), the Uncompahgre Valley Water Users Association (UVWUA), and the Bostwick Park Water Conservancy District. There are also numerous private agricultural ditches in the study area.

The largest supplier of M&I water in the study area at present is the Project 7 Water Authority, which treats and delivers water to the cities of Montrose, Olathe, and Delta, as well as to the rural water systems operated by Tri-County Water Conservancy District (Tri-County), Chipeta Water Company, and Menoken Water Company. Other M&I systems are operated by the municipalities of Gunnison, Crested Butte, Ouray, and Ridgway; the Mt. Crested Butte Water and Sanitation District; the Skyland Metropolitan District; and the Lake City Area Water and Sanitation District.

Additionally, Tri-County is the sole supplier of water from the USBR's Dallas Creek Project. Of the 39,400 af of water available from that project; 28,100 af is allocated for M&I use, 11,200 af is allocated for irrigation, and 100 af is allocated for recreation. Tri-County has commitments from Montrose, Delta and Olathe to purchase 14,000 af Dallas Creek water. Present plans are that the Dallas Creek M&I water will be marketed through Project 7; however, that is not a requirement of Tri-County's agreement with the USBR and could change.

3.3 COLORADO RIVER WATER CONSERVATION DISTRICT

The Colorado River Water Conservation District (CRWCD) is a political subdivision of the State of Colorado, and was formed by the General Assembly in 1937 to conserve and put to beneficial use the waters of the Colorado River in Colorado. The District includes all or part of 15 counties west of the Continental Divide and north of the crest of the San Juan Mountains. The Gunnison River basin represents 8000 of the 29,000 square miles inside the CRWCD boundaries.

In following its mandate to conserve water for use in the Colorado River basin, CRWCD has obtained water storage and diversion rights, assisted in project planning, and intervened in attempts by out-of-basin interests to appropriate water for export. CRWCD has worked closely with Water Conservancy Districts, providing engineering and legal services in protecting their undeveloped water rights. The District has provided such services to both the UGRWCD and the UVWUA in the past.

The CRWCD adjudicated the original water rights for the Aspinall Storage Unit on the Gunnison River, and assigned those rights to the United States. CRWCD also is signatory to the agreements allowing for exchanges of water between Taylor Park Reservoir and Blue Mesa Reservoir.

4.0 EXISTING FISHERY AND RECREATION RESOURCES

This chapter provides a basin-wide overview of the fishery and recreation resources in the study area. Included within the chapter are references to major studies which have been carried out in the study area, an overview of existing recreation facilities and their utilization, descriptions of existing fishery designations and enhancements, and a summary of existing proposals by others for fishery and recreation improvements.

4.1 FISHERIES

4.1.1 Previous Studies

For many years, the trout fisheries existing in the Study Area have been widely acclaimed. As a result, there have been numerous studies of fishery resources in the area. Task Memorandum No. 4, Recreation and Environmental Enhancement Opportunities, prepared and published earlier in the study, identifies and briefly discusses the more important fishery studies that have been carried out in the Study Area.

Numerous water quality measurements and studies have also been carried out in the Upper Gunnison and Uncompahgre Basins in the past. These studies are also discussed in Task Memorandum No. 4.

4.1.2 Existing Stream, Reservoir and Lake Classifications

The Colorado Division of Wildlife has established two types of specially designated waters which are set apart from all other waters of the state. Gold medal trout waters are the highest quality aquatic habitat for trout that exists in Colorado and which offer the greatest potential for trophy trout fishing and angling success. For gold medal designation; a lake, reservoir, or stream must contain at least 40 lbs of fish per surface acre of water, and at least 12 fish per acre must be longer than 14 inches. There are no gold medal trout streams or lakes located in the study area, however, the Gunnison

River from the upstream boundary of the Black Canyon of the Gunnison National Monument to its confluence with the North Fork of the Gunnison River is designated as a gold medal and a wild trout water. Wild trout waters are waters which support a naturally reproducing and self-sustaining trout population without artificial stocking. Within the study area, wild trout waters have been established on Cochetopa Creek, Los Pinos Creek, and on the East River as shown in Figure 4.1. All other streams, lakes and reservoirs within the study area are presently unclassified by the CDOW.

The Water Quality Control Commission, as a result of Colorado Water Quality Control Act (25-8-102(2)C.R.S., 1973), has the authority and responsibility to maintain and improve Colorado water quality. To achieve this goal, the Commission has designed a classification and water quality standards system based on criteria developed by the Environmental Protection Agency (1976). The five general categories of classification include recreation, aquatic life, existing high quality waters, domestic water supply, and agriculture. Only the first three classifications have been assigned to the streams of interest in this study.

4.1.3 Existing Improvements for Fisheries

Significant improvements of the fisheries within the study area have been made in the past. Methods used include special fishery regulations to control the harvest of fish on wild trout and on other waters as shown in Figure 4.1; fish stocking to increase the number of fish available to be caught, and habitat improvements as shown in Figure 4.2. Habitat improvements previously constructed include, among others, the placement of boulders and logs to create additional pools in short segments of the Taylor River, Spring Creek, Slate River, Cebolla Creek, and Gunnison River; acquisition of public access easements on the Gunnison River above Blue Mesa Reservoir; and streamflow and lake level management for fisheries on the Taylor River and Taylor Park Reservoir.

Improvements in water quality have also benefited fisheries. Development of a mine waste treatment facility at the Keystone Mine above Crested Butte has improved the water quality of Coal Creek, a tributary of the Slate River.

Streams in the study area with special regulations that limit anglers to the use of artificial lures and/or artificial flies include segments of Archuleta Creek, Cochetopa Creek, Los Pinos Creek, East River, Gunnison River below Almont, and the Lake Fork of the Gunnison as shown on Figure 4.1. The same segments of Archuleta Creek, Cochetopa Creek, and Los Pinos Creek are designated as catch and release waters also. Special regulations on Blue Mesa Reservoir, Taylor Park Reservoir, and Lake San Cristobal limit the bag, possession and size limit for Mackinaw trout to one fish 20 inches or larger. Other special regulations allow snagging of Kokanee salmon on Blue Mesa Reservoir, Morrow Point Reservoir, and Taylor Park Reservoir from September 1 to January 31.

A major enhancement project was undertaken by the CDOW in 1987 on the 5-mile stretch of the Gunnison River immediately downstream of Almont, Colorado. In the fall of 1987, the Colorado Wildlife Commission authorized a new special regulation for that segment of the Gunnison River which limits fishing to artificial flies and lures only and the bag, possession and size limit to two trout 16 inches or larger. This regulation is part of a program intended to establish a self-sustaining wild rainbow trout population in the Upper Gunnison River. The objective of the enhancement program is to develop a trophy size fishery that will support many more fishermen at less cost than was possible with the previous put and take fishery.

Locations where catchable (6 inches +) trout were stocked in 1986 and/or 1987 are shown in Figure 4.2. A stocking program in 1982 on the Lake Fork of the Gunnison between Sloan Lake and the townsite of Sherman involved the reintroduction of the Colorado River cutthroat trout, a native species.

In 1985, the Colorado Division of Wildlife began restocking brook trout into Lake San Cristobal and began to reduce the number of stocked rainbow

trout in an experiment to restore the excellent brook trout fishery which once existed in the lake.

The Colorado Division of Wildlife has developed a program known as "Fishing is Fun in Colorado," that is intended to improve the state's fishing while increasing the recreational and economic benefits of fishing for all of Colorado. The Fishing is Fun in Colorado program matches local money and/or donated services with Federal dollars from excise taxes on the sale of fishing and boating gear. This enables communities, counties, water districts, businesses, schools, and local fishing conservation and nature groups to take an active role in enhancing their favorite fishing areas. Major areas of emphasis include facilities such a boat ramps and fishing pier construction or renovation, public access improvement, habitat improvement, and public awareness and education. A "Fishing is Fun" enhancement that was undertaken in the study area in 1987 is the production of fishing brochures and maps of four drainages in the Lake City area by the Hinsdale County Fishing Task Force.

4.1.4 Currently Planned Improvements for Fisheries

A large number of specific improvements are currently planned although not necessarily funded for streams, lakes, and reservoirs within the study area. The BLM, CDOW, U.S. Forest Service (USFS), and Trout Unlimited (TU) have developed five-year plans for construction of instream structures and other habitat improvements on reservoirs and segments of streams throughout the Upper Gunnison Basin including among others; Curecanti Creek, Red Creek, East Elk Creek, Slate River, Cement Creek, Brush Creek, Spring Creek, Taylor River, Texas Creek, Tomichi Creek, Hot Springs Creek, Long Branch Creek, Needle Creek Reservoir, Cochetopa Creek, Los Pinos Creek, McDonough Reservoir No. 2, Cebolla Creek, Blue River, and Cimarron River.

Relatively minor improvements have been planned by the CDOW often in cooperation with the NPS, BLM, or USFS for Morrow Point Reservoir, Soap Creek (budgeted), West Antelope Creek, East Elk Creek, Beaver Creek, Quartz Creek,

Razor Creek, Upper and Lower Dome Reservoirs, Lake Fork of the Gunnison River, and Henson Creek. The CDOW is planning to install minor improvements in Spring Creek Reservoir and the Potholes Reservoirs, which will improve cover for trout.

The CDOW is actively studying the newly completed Ridgway Reservoir and the Uncompahgre River downstream to determine the extent to which the reservoir and river will support a trout fishery. No specific improvement measures for the reservoir or river have yet been formalized, however.

4.2 WATERFOWL AREAS

4.2.1 Existing Waterfowl, Wetlands, and Riparian Systems Data

Management prescriptions established by the USFS for wetlands and riparian areas in the Land and Reservoir Management Plan for the Grand Mesa, Uncompahgre, and Gunnison National Forests (1983a) include goals to provide healthy, self-perpetuating plant communities, meet water quality standards, provide habitats for viable populations of wildlife and fish, and provide stable stream channels and still water-body shorelines.

Riparian areas as defined by the USFS include the aquatic ecosystem, the riparian ecosystem (characterized by distinct wetland vegetation), and adjacent ecosystems that remain within approximately 100 ft measured horizontally from both edges of all perennial streams and from the shores of lakes and other stillwater bodies. Specific riparian areas are not identified in the plan or its accompanying environmental impact statement (USFS, 1983b).

The BLM (1981a, 1981b) established objectives for riparian area maintenance and improvement in its management framework plans for the American Flats/Silverton area and the Gunnison Basin. The BLM (1977, 1980b) has mapped major riparian areas and estimated acreages of riparian lands in grazing allotments throughout the Gunnison and Uncompahgre basins.

The Colorado Division of Wildlife (1987) maintains species lists for wildlife including water birds for discrete areas throughout the state known as Latilongs. Each Latilong covers an area defined by one degree of latitude and one degree of longitude. Nearly all of the study area is incorporated within three Latilongs; Latilong 17 which covers the study area east of Gunnison, (east of 107 degrees longitude), Latilong 16 which covers the area between Gunnison and Montrose (107 degrees longitude to 108 degrees longitude), and Latilong 15 which covers the area west of Montrose and north to Delta (west of 108 degrees longitude). Latilongs 15, 16, and 17 fall between 38 degrees and 39 degrees of latitude.

The Colorado Department of Game, Fish and Parks (1968) conducted a statewide inventory and evaluation study of wetlands for waterfowl hunting. Wetlands inventory objectives were to: 1) determine the amount and distribution of wetlands in the four major waterfowl wintering regions of Colorado - the South Platte Valley, the Arkansas Valley, the San Luis Valley, and the Uncompahgre-Gunnison-Colorado River complex; 2) determine the number and amount of wetlands leased for hunting and other recreational purposes; and (3) develop a method of rating wetlands as public hunting areas.

AMAX (1981) briefly studied vegetation, wetlands, and waterfowl in the East River, Slate River, Ohio Creek, and Alkali Basin as a part of its environmental impact assessment for the proposed Mt. Emmons molybdenum mining project. The U.S. Bureau of Reclamation (1984c) addressed wetlands as a part of its assessment of environmental impacts of salinity control measures proposed for the Uncompahgre Basin. In July 1986, the Federal Aviation Administration prepared a wetlands restoration and mitigation plan for the Gunnison County airport expansion project.

The Natural Energy Resources Company (1987) studied the waterfowl present in Latilong 17. They also mapped and described vegetation including wetlands in the project area surrounding the Rocky Point Pumped Storage Project.

4.2.2 Existing Waterfowl Areas

Major waterfowl nesting areas and popular waterfowl hunting areas identified during interviews with CDOW Division Wildlife Managers are shown on Figure 4.3.

Numerous other small wetland areas not identified on the figure are present throughout the study area near streams, lakes, springs, and agricultural drainage areas.

4.2.3 Recreational Use of Waterfowl Areas

Wetlands throughout the study area are popular for the observation and feeding of waterfowl. Some limited hunting of migratory waterbirds occurs in the Upper Gunnison Basin. Due to the lack of a supply of grain in the Upper Gunnison Basin and the mountainous environment, the numbers of migratory ducks and geese are relatively few. Resident ducks in the Upper Gunnison Basin feed largely on vegetation and insects which render them less desirable for human consumption. The Uncompahgre Valley offers an excellent grain supply and good habitat for migratory waterfowl. Hunting for ducks and geese is extremely popular. Hunting pressure on wetlands and waterfowl areas in the Uncompahgre Valley is often such that waterfowl are often unable to find adequate locations for rest and seclusion which causes them to move out of the area.

4.3 WATER-BASED RECREATION

4.3.1 Recreation Studies and References

Public lands within the study area are administered by the CDPOR, the CDOW, the NPS, the BLM and the USFS for multiple purposes, including recreation. Specially designated recreation, wilderness, and wildlife areas are shown in Figure 4.4 The area provides an abundance of outdoor recreation opportunities. There have been a number of recreation related studies performed by or for state and Federal resource management agencies. These

studies are identified and described in Task Memorandum No. 4 and are also included in Appendix A, Bibliography.

4.3.2 Existing Recreational Facilities and Improvements

Approximately 72 percent of the study area is made up of public lands which are managed to provide recreation among other purposes. The CDPOR, the CDOW, the NPS, the BLM, and the USFS administer recreational facilities within the study area. Numerous private resorts, campgrounds and RV parks are dispersed throughout the remaining 28 percent of the study area.

The following is a summary of developed campsite locations within the study area:

Responsible Entity	Developed Campsites
CDPOR (under construction)	280
CDOW	0
Hinsdale County	30
National Park Service - Curecanti	452
National Park Service - Black Canyon	115
U.S. Bureau of Land Management	32
U.S. Forest Service	609
Private	1280
Total	2800

The location of developed public recreation facilities in the study area is shown in Figure 4.5.

4.3.2.1 Colorado Division of Parks and Outdoor Recreation

The CDPOR operates the Sweitzer Lake State Recreation Area 2 miles southeast of Delta. Sweitzer Lake has no campsites. Popular activities

include fishing, boating, picnicking, hiking, waterfowl hunting, and sightseeing. Sweitzer Lake is a 137-acre reservoir. This recreation area experienced 102,758 visitor days between July 1, 1986 and June 30, 1987 nearly all of which were associated with water-based recreation. Approximately 8670 visitor days were for fishing.

The CDPOR will operate the Ridgway State Recreation Area which is currently under construction at Ridgway Reservoir and is scheduled to open in 1989. The recreation area will include 2280 land acres and 1180 surface acres of water. The reservoir will be approximately 5 miles long and 1 mile wide. Recreational opportunities will include fishing, boating, water skiing, wind-surfing, picnicking, hiking, bicycling and camping. Plans call for development of a marina, beach, park headquarters, trails and two campgrounds with a combined total of approximately 280 campsites. Visitation is expected to reach 350,000 persons per year following completion of park facilities in 1991-92.

4.3.2.2 Colorado Division of Wildlife

The CDOW manages state wildlife areas within the Study Area including approximately 18,000 acres within Beaver Creek, Cimarron, Cebolla, Dome Lakes Roaring Judy, and Sapinero Wildlife areas in the Upper Gunnison Basin; and 6000 acres in the Billy Creek Wildlife Area in the Uncompahgre Basin. These areas are managed primarily for the protection and benefit of wildlife and have no developed recreation facilities other than parking areas and information signs. The areas are used, however, for such dispersed activities as wildlife viewing, hunting, and fishing. No estimates of recreational use of State Wildlife areas within the study area are available. However, because the areas are relatively inaccessible, recreational use is probably a very small percentage of total recreational use in the study area.

The CDOW manages perpetual fishing easements on the Lake Fork of the Gunnison River, on Cochetopa Creek, and on Los Pinos Creek. The CDOW provides parking areas, information signs, and fence crossing points at these

locations. The CDOW owns and operates Spring Creek Reservoir for fish and wildlife purposes. Developed recreation facilities (Mosca Campground) on Spring Creek Reservoir are operated by the USFS.

4.3.2.3 National Park Service

The NPS manages the Curecanti National Recreation Area and the Black Canyon of the Gunnison National Monument. The Curecanti National Recreation Area was established in 1965 under the authorization of the Colorado River Storage Project Act and covers more than 40,000 acres of land. With three reservoirs, much of the activity is water-based and includes fishing, boating, water skiing, swimming and windsurfing. There are currently two marinas and five boat launch ramps on Blue Mesa Reservoir. Camping is provided for at ten designated campground facilities on a first-come first-served basis. These are generally closed by snow from December through March. Remote and back country camping is provided for at 47 sites, some of these are accessible only by boat or hiking. A total of 452 campsites have been developed within the recreation area. In addition to water-based activities, Curecanti offers 17 miles of hiking trails. Off-season visitors are attracted by spring wildflower displays and the variety and abundance of wildlife in the fall and winter seasons. Ice fishing on Blue Mesa Reservoir is very popular.

The Curecanti National Recreation Area is the most heavily used recreation facility in the study area. In 1986, there were 1,114,756 visits to the park, essentially all of which were water-related. This figure includes 224,744 fisherman visits. Table 4.1 provides visitor use data from 1982 through 1986. Table 4.1 also shows specific use data for fishing, boating, swimming, windsurfing, water skiing and picnicking. Fishing and boating on Blue Mesa Reservoir are the most popular water-based activities.

The Black Canyon of the Gunnison National Monument was established in 1933 to protect and preserve the gorge of the Gunnison River. The majority of access and visitor use is on the tops of dry mesas which provide scenic overlooks 2000 to 3000 feet down into the gorge. Developed facilities include

two campgrounds with 115 campsites, a picnic area and many scenic overlooks, all located on top of the mesas. The East Portal area, located at the eastern or upstream boundary of the national monument provides the sole access (automobile or pedestrian) that is available to the Gunnison River in the monument. The East Portal is a popular fishing area, with access available to 3/4 mile of gold medal trout fishing waters.

The Black Canyon of the Gunnison National Monument received 289,000 visitors in 1986. Table 4.2 shows annual visitation for the last decade. Ninety percent of the visitors to the Black Canyon are day users. One night campground use accounts for nearly all the rest. The overwhelming visitor use is scenic viewing of the canyon. All other uses including fishing, hiking, climbing, and picnicking by comparison are minor. There is very little rafting through the monument. Only two to three special use permits for rafting are issued each year which limits the total number of persons using the river each year to less than ten.

4.3.2.4 U.S. Bureau of Land Management

The BLM manages approximately 580,000 acres of multiple purpose lands in the Upper Gunnison Basin and 170,000 acres of lands in the Uncompahgre Basin within the study area. Large tracts are located in the Cebolla Creek, Lake Fork of the Gunnison, and Cochetopa Creek drainages and at intermediate elevations along the east and west margins of the Uncompahgre Valley. There are three special recreation management areas (SRMAs) located on major streams within BLM lands in the study area. The American Flats/Silverton and Lower Lake Fork SRMA, the Cochetopa Canyon SRMA, and the Gunnison Gogre SRMA are shown in Figure 4.4. The Powderhorn Primitive Area is an important undeveloped recreation area and also includes an SRMA. This area provides back country fishing opportunities.

The American Flats/Silverton and Lower Lake Fork SRMA covers approximately 135,000 acres of the San Juan Mountains between Lake City, Silverton, and Ouray, approximately 2/3 of which is located in the Study Area.

The area is popular for motorized recreation (jeeping and motorcycling), sightseeing, camping, fishing, and other recreational pursuits. The Lake Fork of the Gunnison River which has good motorized access is located within the SRMA and is the BLM's most heavily used water-based recreation corridor. The Lake Fork has two very popular campgrounds (see Figure 4.5) and numerous parking/access areas for day use activities including fishing. A limited amount of whitewater boating takes place on the Lower Lake Fork. The BLM has 27 developed and several primitive campsites in the American Flats/Silverton and Lower Lake Fork SRMA within the study area. Hinsdale County provides 30 public campsites at Wupperman Campground on Lake San Cristobal in the SRMA. Hinsdale County owns and manages most of the shoreline and immediately-surrounding lands on Lake San Cristobal. The BLM has five developed campsites in the nearby Cebolla Creek drainage.

Recreation use in the American Flats/Silverton and Lower Lake Fork SRMA, total visitor use in 1984 was estimated to be 552,000 recreational user days (RUD's) (BLM, 1986a). Roughly 380,000 RUD's of the use described above took place in the study area. In the same year, approximately 45,900 visitor days were spent by fishermen in the Upper Lake Fork and Henson Creek Drainages; and 20,000 visitor days were expended in water-based activities on the Lower Lake Fork, of which 3000 days were spent by fishermen. Approximately 133,000 visitor days were spent in the SRMA by visitors who listed fishing as one of their top five reasons for visiting the SRMA. These are visitors for whom the presence of water and water-based recreation opportunities are important. Mill Creek Campground on the Upper Lake Fork, which has 22 campsites, is the only BLM campground in the study area for which use data is available. The Mill Creek Campground had about 2800 users in 1986, for a seasonal utilization rate of about 27 percent.

The CDOW estimates that approximately 12,000 angler days of fishing take place on Lake San Cristobal annually based upon creel census data and fishing pressure determinations. Approximately 4000 RUD's of use are experienced in the Powderhorn SRMA.

The Cochetopa Canyon SRMA is a 4-mile long corridor established along Cochetopa Creek. Colorado State Highway 114 closely follows the alignment of the creek through the canyon offering very easy access to the SRMA and Cochetopa Creek. The area is heavily used by travellers as a roadside rest stop, by fishermen, and by short- and long-term campers. The BLM has approximately 23 primitive campsites in the SRMA but there are no developed recreation facilities or campgrounds. The Slate River above Crested Butte has approximately 1 mile of BLM land ownership available for fishing, picnicking, and one or two primitive campsites.

In the Cochetopa Canyon SRMA, very rough estimates of visitation were made in 1983 and 1984 (BLM, 1987b). During the summer, the area received approximately 10,700 water-based visitor days of use for camping, fishing, and picnicking of which approximately 699 visitor days were for fishing.

The BLM has established a Special Recreation Management Area for approximately 64,000 acres of lands in and surrounding the Gunnison River in the Gunnison Gorge downstream of the Black Canyon of the Gunnison National Monument. The area is known for excellent fishing and for whitewater rafting. Most of the inner gorge (approximately 20,000 acres) is managed as a wilderness study area with motorized travel prohibited and access limited to trails and rafts. Developed facilities within the Gunnison Gorge are limited to trails, trailhead parking areas, RV unloading ramps, visitor signs and displays. The BLM does not have any developed campgrounds in the Gunnison Gorge SRMA.

In 1983, visitor use data collected in the Gunnison Gorge (BLM, 1985) totalled approximately 4000 visitor days at the Gunnison Forks (the sole automobile access point) plus 700 visitor days at the Ute and Chucker Trail (non-motorized access only). Data collected by the BLM and the CDOW indicate that approximately 3700 fishermen fished the entire gorge in 1986 from the banks and rafts (BLM, 1986b) for a total of approximately 7000 fishermen. Rafting in the Gunnison Gorge has dramatically increased in recent years. Data collected during 1986 indicates that between June 11 and September 12,

1986, a total of about 1380 persons took private and commercial boat trips in the gorge. These persons entered via the Chucker, Durango, Ute and Bobcat Trails to begin their trips. It should be noted that the data understates total visitation because not all private boaters register with the BLM. This was an 80 percent increase in visitation over the same period for 1985 (BLM, 1986c). In 1987, the maximum carrying capacity of the river of 75 people per day (as established by the Gunnison Gorge Advisory Group) was exceeded on nine days. It is likely that total use of the gorge approached 10,000 visitor days in 1987. As a result of the increased use, the BLM has announced a moratorium on issuing new commercial outfitter recreation permits for 1988.

The best estimate by BLM staff of recreation use (Arden Anderson, personal communication) is 230,000 RUD's for the Uncompahgre Sub-basin and 200,000 RUD's for the Upper Gunnison Basin for BLM lands outside of the SRMA's. While these lands cover a large area and are popular for dispersed activities including hunting, recreational driving, and wood cutting, there is very little water-based recreation or fishing use except on 2 miles of Cebolla Creek and 1 mile of the Slate River. Accordingly, a rough estimate of water-based recreational and fishery use for all BLM lands in the study area is about equal to the use for these SRMA's. Annual recreational use for BLM lands in the Study Area for 1986 is summarized as follows:

	RUD's
BLM total recreation use	835,000
BLM water-based use	154,000
BLM fishery use	63,000

The BLM does not have any developed campgrounds in the Uncompahgre River basins.

4.3.2.5 U.S. Forest Service

Lands managed by the USFS in the Study Area cover approximately 55 percent (1,287,000 acres) of the Upper Gunnison Basin and 19 percent (141,000 acres) of the Uncompahgre Basin. The lands are located within the Grand Mesa, Uncompahgre and Gunnison National Forests which are administered by the USFS as a single unit.

The National Forests accommodate a wide variety of recreational activities. Developed recreation activities take place at developed sites such as campgrounds, picnic areas, boat launching areas, and scenic overlooks. Developed recreational activity accounts for approximately 28 percent of recreational use of the Grand Mesa, Uncompahgre, and Gunnison National Forest. Dispersed recreational uses include all fishing, hunting, back country and primitive camping, hiking, and recreational driving. Dispersed recreational uses occur throughout the forest and accounts for approximately 72 percent of total recreational visitation. The National Forests include all or part of the following six wilderness areas: West Elk, Big Blue, Mount Sneffles, Maroon Bells-Snowmass, Collegiate Parks, and the La Garita. These wilderness areas total some 309,000 acres and are shown in Figure 4.4. The Taylor River and Taylor Park area is specially recognized by the Forest Service for its recreational value and is a concentrated area for both developed and dispersed recreational activities. A plan to guide recreation development and management in the Taylor Park area is currently being prepared by the USFS.

There are numerous developed Forest Service recreation sites throughout the Upper Gunnison and Uncompahgre Basins. Within the Study Area there is a total of 39 Forest Service campgrounds with 609 campsites, of which 36 campgrounds with 556 campsites are located immediately adjacent to water and offer water-based recreation opportunities. Campground locations are shown in Figure 4.5. Forest Service campgrounds are administered by Ranger District. The location of Ranger Districts within the study area is shown in Figure 4.6. There are four USFS picnic areas with approximately 20 picnic sites located on streams in the study area.

There are no developed boat launching or take-out facilities on streams within Forest Service lands in the study area. Primitive boat launching areas are available on the Taylor River below the confluence with Crystal Creek and at Almont. The USFS has a developed boat ramp on Taylor Park Reservoir which is privately operated under a special use permit, and a public boat ramp on Spring Creek Reservoir.

In 1986, all developed and dispersed recreational activities in the Taylor River, Cebolla, and Ouray Ranger Districts of the Grand Mesa, Uncompahgre, and Gunnison National Forest totalled 1,132,000 recreational visitor days. The total area covered by the Taylor River, Cebolla and Ouray Range Districts is roughly equal to the area covered by USFS lands within the study area (see Figure 4.6). A very small portion of the Paonia Ranger District also lies within the study area. Since that particular area is small and water-based recreation opportunities are very limited, recreation use figures from the Paonia District were not included within the study area estimates.

Tables 4.3, 4.4, and 4.5 show the developed recreation use at water-based campgrounds in the ranger districts in the study area. Table 4.3 shows data for the Taylor River District. The data is shown first for the eight campgrounds on the lower end of the Taylor River. These campgrounds receive by far the heaviest Forest Service use in the study area. They are always full on weekends during the peak of the camping season and generally on many weekdays. These campgrounds had an overall 39 percent seasonal utilization expressed as a percentage of theoretical capacity. Theoretical capacity is calculated assuming a 95-day summer season, five persons at one time per site, and two RVD's per person per day (see Section 4.3.2.9).

The remainder of the campgrounds in the Taylor River District are also shown in Table 4.3. There are a total of 323 camping sites in the Taylor River District campgrounds. In 1986, these provided for 113,249 user days. The overall seasonal utilization for campsites in the Taylor River District was 37 percent.

Campground use data for the Cebolla District is shown in Table 4.4. There are 140 water-based campsites in the district which received 34,000 RVD's of use in 1986, resulting in an overall seasonal utilization of 25 percent. There are 93 water-based campsites in the Ouray District, which received 8919 RVD's of use in 1986, for a seasonal utilization of 10 percent (see Table 4.5).

Throughout the study area, the USFS campgrounds located on rivers, streams, lakes and reservoirs have a total capacity of 556 sites. These campgrounds provided for 156,168 RVD's for a total overall seasonal utilization of 30 percent.

For 1986, all water-based recreation uses (both developed and dispersed) for the Taylor River, Cebolla, and Ouray Ranger Districts totalled 380,700 RVD's, and fishery use totalled 54,200 RVD's. A breakdown of all recreation, water-based recreation, and fishery use by ranger district for the years 1983 to 1986 is provided in Tables 4.6 and 4.7. These data were obtained from the Resource Information Management or RIM system operated by the USFS. The reliability of this data varies throughout the districts. Some of the visitor use data reflects actual counts taken at developed recreation sites throughout the summer season. Other data is an extrapolation of a few sample counts for certain sites. Other use data is an educated guess based on the "gut feel" of staff who are familiar with the district.

The RIM data was evaluated for each of the districts with the help of Forest Service personnel in an attempt to determine what data reflects water-based recreation and what data represents recreational use that is not along a watercourse or water body. In Table 4.7, data is presented for water-based developed recreation sites which includes boat docks, campgrounds, and picnic grounds along waterbodies. Data presented in Table 4.7 for dispersed use includes fishing, kayaking, hiking, back country camping, and recreational use of unimproved roads adjacent to water.

4.3.2.6 Private Campgrounds and RV Parks

Private campgrounds and RV parks offer significant recreational opportunities in the study area. Unless otherwise indicated, the estimates below are based on interviews with campground owners and local chambers of commerce. Within a 10-mile radius of the City of Gunnison, there are approximately eight campgrounds and RV parks with a total of approximately 400 campsites and RV spaces. There are approximately 40 private RV sites adjacent to Blue Mesa Reservoir available to the public on a nightly basis. Lake City has at least three campgrounds and RV parks. An accurate estimate of the number of private campsites in Lake City was not available. Considering that the average number of campsites for those campgrounds which were able to be contacted in this study equals about 60 units per campground, a crude estimate of private campsites in Lake City of 180 units is probably reasonable. The cities of Delta, Montrose, and Ouray have three major RV campgrounds each with a combined total of 160, 170, and 330 campsites, respectively.

No estimates of private campground and RV park visitation are available for the Upper Gunnison and Uncompahgre Basins. Private campground operators contacted by telephone were asked to estimate the seasonal occupancy rate for the summer season for their campground. The weighted average of 11 responses to this question was 54 percent. A very crude but conservative estimate of private campground and RV park visitation for the summer may be arrived at by multiplying an occupancy rate of .54 times the total number of campsites available (1280) times the length of the peak summer season (90 days) to arrive at a total of 62,200 visitor days.

4.3.2.7 Whitewater Boating in the Upper Gunnison Area

Three commercial whitewater rafting outfitters offer a variety of float trips and rafting experiences within the study area. Trips are conducted on the Taylor River between the confluence with Lottis Creek and the confluence with the East River, on the Gunnison River between the confluence with the Taylor River and Blue Mesa Reservoir, and on the Lake Fork of the Gunnison

River between Ryan's Bridge (7 miles north of Lake City) and Blue Mesa Reservoir.

Whitewater boating experiences are affected by many factors. These include the river's flow, the level of challenge that each segment of the river provides, the number of portages, the number of river users on a particular river segment and the type of recreation users, i.e., private versus commercial user, novice versus expert boater. Whitewater boating is also affected by how accessible the river is and what types of obstructions it includes. River stretches are classified on a scale of 1 to 6 to reflect the nature of the stream and its gradient. Class 1 water is flat water and Class 6 water is not runable. Most kayakers boat on Class 3 and 4 waters. River classifications are quite subjective. Changes in flows won't necessarily affect the classification. Depending on the channel characteristics, some rivers get more difficult with low water whereas others may be more challenging with high water.

The Taylor River is classified as a Class 3 river from the Taylor Park Reservoir to Lottis Creek Campground. Its gradient is about 62 ft per mile. In Taylor Park Canyon, there are some Classs 3 and 4 rapids. From Lottis Creek to Lodgepole Campgrounds, there are some Class 4 rapids with gradients of 120 ft per mile.

Commercial rafters describe the Taylor River as providing the best whitewater rafting experience of all the streams and rivers in the Upper Gunnison Basin. In 1987, approximately 4000 persons were carried by the three commercial operators and private trips carried approximately 1000 persons on the Taylor River.

The Gunnison River, because of its large size and shallow gradient, is preferred for leisure rafting and fishing by the outfitters and their customers. Roughly 4500 persons participated in commercial rafting on the Gunnison in 1987. Approximately 1000 persons took private rafting trips on the Gunnison in 1987 also.

The Lake Fork of the Gunnison River is utilized for scenic tours between Ryan's Bridge and the Red Bridge Campground. This section is rated mostly Class 2 with some Class 3 rapids that appear during high water. One commercial outfitter allows no fishing from his raft as a goodwill gesture to private landowners who own property adjacent to the river, some of whom maintain private fish stocking programs. Between Red Bridge and Blue Mesa Reservoir, the river gradient is steeper and rated as Class 3 with one rapid that is rated as a Class 4. This section of river is popular for whitewater rafting. Approximately 800 persons took commercial raft trips on the Lake Fork in 1987. The use data cited above was obtained from commercial rafters operating in the Upper Gunnison Basin.

Private rafting groups, boaters, and kayakers primarily utilize the same streams which are used by the commercial rafters. This occurs largely because other streams in the basin are too small, lack access, or are privately owned and fenced. There is a small amount of private boating on the East River. About 65 percent of the total annual streamflow on the East River occurs in late May and June. It is estimated that there are 200 RVD's of private rafting and kayaking use on the East River per year.

Permitting of commercial rafters on the Taylor, Gunnison, and Lake Fork of the Gunnison is administered by the USFS and BLM. Since boating activities take place on USFS and BLM lands, estimates of whitewater boating use have already been included in the recreation activity estimate for those agencies in sections 4.3.3.4 and 4.3.3.5.

4.3.2.8 Skiing

A major developed recreational activity within the study area is downhill skiing. Skier use at Crested Butte Mountain Resort (CBMR), which operates on a USFS lease, was 220,000 RVD's in 1980, 233,000 RVD's in 1983, and 385,000 skier days in 1987. The existing capacity at CBMR is for approximately 6500 skiers at one time, or 550,000 skier days per year. The potential capacity at Crested Butte, with the development program approved by the USFS in their

Master Plan, is for a capacity of 10,700 persons at one time and 900,000 RVD's per season. Out-of-state residents account for 60-70 percent of skiers at Crested Butte.

4.3.2.9 Summary of Recreational Use

Utilization of forest service campgrounds is shown below:

	Utilization
Taylor River District	37%
Lower 15 miles of Taylor River	39%
Cebolla District	25%
Ouray District	10%
Average USFS Campground Utilization for Study Area	30%

These percentages were obtained (following methods used by the USFS) by dividing the annual number of persons using a campground (expressed in recreational visitor days) by the theoretical capacity. The theoretical capacity is determined by taking the product of the number of campsites in the campground, the number of days in the camping season (95 days between Memorial Day and Labor Day), the design capacity of the average campsite (five persons at one time), and the conversion factor between RVD's and days (2.0 RVD's/day. An RVD is counted following 12 manhours accumulated by one or more persons who are present in the campground.)

According to USFS recreation specialists, utilization rates of 30 percent to 40 percent of theoretical capacity represent high utilization rates with all campground units being occupied on major weekends and throughout the week during the peak summer season.

In recent years, the number of persons in the average family or party camping in an individual campsite has declined to about 2.5 persons per campsite. Accordingly, on a night when all the sites or units in a campground

are occupied and there is no room to accommodate additional parties of campers, the utilization in total numbers of persons will be approximately 50 percent of the theoretical capacity. Another way of putting this is that if the only concern is whether a campsite is occupied (i.e., by one or more people in a party) but not whether it is filled to its design capacity of five persons at one time, then the occupancy rates could be considered to be approximately two times the utilization rates shown above.

Seasonal utilization for all campgrounds within the Curecanti National Recreation Area in 1986 was about 51 percent, assuming a 110-day summer season. The figure is not comparable with the USFS figures above because the agencies report visitation differently.

A summary of annual visitation for recreational activities in the study area for 1986 is provided in Table 4.8.

The recreation use estimates above were gathered from separate agencies and locations and should not be added. Unfortunately, the methods of determining visitation by each entity are different and no accurate means of converting between methods is available. The CDPOR and NPS count numbers of visits by individuals without regard to length of stay. The BLM and USFS keep track of recreational user days (RUD's) and recreational visitor days, respectively, which use different definitions of a visitor day. An RUD is defined by the BLM as one visitor spending all or any part of a day on BLM land. An RVD is defined by the USFS as 12 visitor hours which may be aggregated continuously, intermittently, or simultaneously by one or more persons. A single person may accumulate up to two RVD's per day at a USFS facility. Nevertheless, these figures do provide a useful insight into the total recreational use in the study area.

The Gunnison County Chamber of Commerce conducted surveys of drop-in visitors to the Chamber office in July and August of 1985 and 1986 that provide a good picture of the summer tourist in Gunnison County. Of those tourists who participated in the survey, 44 percent fished, 31 percent camped

and 12 percent went on a raft trip. The average amount of money spent while visiting Gunnison County was $36.07 per person per day. More tourists that participated in the survey stayed in motels than camped. The following table presents a breakdown of the percentage of visitors surveyed by the Chamber of Commerce that stayed in hotels, camped or had other accommodations.

Accommodations - Gunnison County Visitors

Type of Accommodation	Percentage
Hotel	49
Camping	16
Recreation Vehicle	19
Family/Friends	6
Other	10

Many of the visitors to the study area who stopped into the Chamber offices are seniors. The Gunnison Chamber of Commerce survey showed 10 percent to be under 30 years, 10 percent from 30-39 years, 23 percent from 40-49 years, 23 percent from 50-59 years and 24 percent over 60 years of age. Visitation data from Curecanti shows that 48 percent of the park visitors were 62 years and older.

4.3.3 Currently Proposed Improvements for Recreation

Interviews were conducted with staff of the many land management and planning agencies that have jurisdiction in the study area to determine what specific proposals existed for new recreational areas or facilities. In many instances, the resource agency and planning agency staff had ideas for potential recreation areas, but in some cases these had not been formalized into planned projects.

The CDPOR has a five-year plan for Sweitzer Lake which calls for $729,600 to be spent on improving and adding to facilities at the site.

The Colorado Division of Wildlife (CDOW) plans to construct a parking area for fishermen and to put up public information signs along Cebolla Creek. This will be located on CDOW property on the east side of the Cebolla Creek Wildlife Area (see Figure 4.5). They are also continuing with stream improvements on Spring Creek. The CDOW, in conjunction with the Bureau of Reclamation, recently purchased three large land parcels on Beaver Creek. The Division of Wildlife plans to construct a parking area and to put up public information signs in these new areas.

The Bureau of Reclamation, as part of their fish and wildlife mitigation program for the Aspinall unit, plans to acquire 26 miles of public stream fishing easements. No specific locations for these purchases have yet been determined. The CDOW will prioritize reaches of river for this acquisition. The acquired lands will be managed by the CDOW or by the USFS or BLM if the land is a key parcel adjacent to other property they administer. Acquisition of these parcels is included in the Bureau of Reclamation budget plan, but implementation is dependent on appropriation of funds.

The U.S. Forest Service, in its Land Resource Management Plan for the Grand Mesa, Uncompahgre and Gunnison National Forest (1983a),included, as Appendix A, a Capital Investment Plan for Developed Recreation. This plan addresses new construction capital investment needs for the next 50 years. It also addresses the capital needs for rehabilitation of existing facilities during the next 15 years.

Current programs in the Capital Investment Plan for Developed Recreation are to expand the Rivers End and Lottis Creek Campgrounds to 45 sites each. That project is shown on the plan for the year 2002. Another is to expand Deer Lakes Campground, in the Cebolla District, to 40 sites. That project is scheduled for 2008. A similar expansion to 40 sites is programmed for the Gothic and Avery Peak Campgrounds in the year 2016. Campground rehabilitation actions are scheduled for many of the existing USFS campgrounds in the Taylor, Cebolla and Ouray Districts. Implementation of the plan is subject to funding appropriations and availability. Some recent shifts in those plans have

occurred. New plans for the Taylor River District include future development of a 30-unit recreational vehicle camp on Taylor Park Reservoir near the boat house.

Recreation specialists in the USFS Taylor River District consider the construction of new campgrounds and improvements of existing campgrounds in Taylor Park and in the Taylor River Canyon to be their highest priority recreation improvement in the district. Ten new campsites are slated for construction in 1988 as a part of the rehabilitation of the Lakeview Campground. The Taylor River Ranger District has applied for funding to reconstruct the Lottis Creek, Rosy Lane, One Mile, and Dinner Station Campgrounds in 1989. Major improvements planned at the campgrounds include the construction of new handicapped toilets, modernization of camp units, reconstruction of roads and spurs, and construction of new campground host units. Total project costs for all four campgrounds are projected at $488,950. One of the highest priorities at these and other forest service campgrounds is to lengthen and level the parking spurs for the types of recreational vehicles that are currently in use. The Taylor River District's highest priority for a new campground is to construct a state-of-the-art recreational vehicle park on the shores of Taylor Reservoir. The campground would house approximately 30 relatively closely spaced sites. The district would like to attain funding for the campground in the next one to two years. The Taylor River District would also like to reconstruct the Avery Peak Campground and construct ten new campsites on the East River above Gothic. The Cebolla Ranger District has applied for funding to reconstruct the Pitkin and Williams Creek Campground in 1989.

The Bureau of Land Management has specific proposed plans for development along Cochetopa Canyon. These plans are set forth in the Preliminary Draft of the Recreation Area Activity Plan for the Cochetopa Canyon Special Recreation Management Area (1987b). These plans call for developing nine sites along Cochetopa Canyon with up to 32 campsites. Plans also call for putting in parking areas for 20 vehicles, toilets and a number of educational information

signs. This would increase the BLM's capacity for camping and picnicking in the SRMA by 40 percent.

The BLM has no plans at present to construct any developed facilities in the Gunnison Gorge other than to improve sanitary facilities and signage at several primative locations.

The BLM's management plan for the American Flats/Silverton and Lower Lake Fork special recreation area indicates the BLM will continue, as funding permits, obtaining access for fishing and other recreation. They also are developing special maps and brochures of their recreation areas. The BLM plans to build a small parking area adjacent to Highway 149 between Lake City and Lake San Cristobal to provide access to the Lake Fork. They also plan to develop a small parking area and footbridge near the confluence of Alpine Gulch and Henson Creek. Development of toilets is scheduled for several areas including the Silver Creek Trailhead, Cunningham Gulch Road, Minnie Gulch and the Eureka Townsite.

The Curecanti National Recreation Area, administered by the National Park Service, is included within pending legislation which would shift the authorization for the recreation area from the Colorado River Storage Project Act to separate statutes under the National Park Service. Until this legislation is passed, Curecanti has no plans for construction of additional recreation facilities. In the future, however, sufficient demands will exist that another marina and additional campgrounds would be desired (interviews with Dan Peregoy, Assistant Superintendent, Curecanti NRA).

A citizen's alliance has been organized in Montrose for the purpose of creating a recreational corridor along the Uncompahgre River that would provide opportunities for bicycling, hiking, fishing, and rafting. The corridor would extend from Montrose to Ouray along the old Denver and Rio Grande Western Railroad tracks and provide access points to the Uncompahgre River.

4.4 PUBLIC ACCESS

4.4.1 Access Studies and References

Federal and state agencies often address public access as a part of their responsibility for managing and developing public resources within the study area. The CDOW (no date), as a part of its stream and lake survey program, has measured private versus public ownership on most major streams and lakes in the study area. The CDOW periodically reviews fish stocking agreements with private landowners to see that conditions requiring free public access with permission are being met.

The U.S. Bureau of Reclamation and the Colorado Division of Wildlife have conducted unpublished evaluations of alternatives for acquiring public access as a part of the mitigation for the Aspinall Unit of the Colorado River Storage Project. In 1977, the CDOW developed proposals for mitigation of the Aspinall Unit listed by priority which included recommendations to acquire private lands for public uses on the East River, Lake Fork of the Gunnison River, and Tomichi Creek. Other recommendations for access were also made for Cochetopa Creek, Taylor River, Lily Pond, Middle Quartz Creek, and Cebolla Creek. In the early 1980's, the USBR investigated the potential of acquiring public access on the Uncompahgre River as a part of its mitigation for Ridgway Dam but could find no private landowners who were interested in selling property at the time.

The U.S. Forest Service (1983a) identified the following goals for land ownership in its Land and Resource Management Plan for the Grand Mesa, Uncompahgre, and Gunnison National Forests:

1. Increase opportunities for exchange and transfer of National Forest System land.
2. Acquire rights-of-way needed to support management of National Forest System resources.
3. Post and mark the forest boundary.

The forest plan projects a total annual exchange of land with private landowners of 240 acres per year between the years 1991 and 2030 for the three forests combined.

The U.S. Bureau of Land Management (1981a, 1981b) placed a priority upon improved access to lands for recreational purposes in its management framework plans for the American Flats/Silverton area and the Gunnison Basin. The BLM (1977, 1980b) summarized acres of BLM land ownership and miles of BLM lands on streams in the Gunnison and Uncompahgre Basins. In its management plan for the American Flats/Silverton and Lower Lake Fork Special Recreation Area, the BLM (1986a) established the following management guidelines for land acquisition, easements, and access:

1. Pursue a flexible program of land exchange within the SRMA with the general goal of consolidating public land holdings for more effective management and the acquisition of private parcels that degrade or threaten the area's recreation potential. Acquisition would be achieved by BLM land exchange with willing land owners.

2. Whenever possible and desirable, retain fishing and/or access easements on all public lands selected for sale or exchange within the SRMA.

3. Where desirable, secure public access to public lands "landlocked" by private ownership. Easement acquisitions would be achieved through negotiations with willing land owners.

These guidelines relate to specific needs in the area. As an example, the BLM has a land parcel with 1/3 mile of excellent fishery on the Lake Fork of the Gunnison 12 miles north of Lake City which is separated from Colorado Highway 149 by an unbroken but very narrow strip of private land. The private land prevents any public access to the fishing which is available on the BLM property. In the same plan, the BLM specified the following actions specifically for the Lower Lake Fork.

1. In cooperation with state and county agencies, the BLM should seek to augment and improve public fishing opportunities along the Lower Lake Fork by appropriately signing existing public land and public fishing easements and by constructing small vehicle parking areas off the highway on BLM land. Consideration should be given to cooperating with the CDOW in identifying appropriate easements which could be acquired through Section 8 mitigation by the Bureau of Reclamation.

2. If the Thomas exchange property adjacent to the Gate is acquired, consider development of a public campground on the tract to accommodate overnight use and fishing/hunting access.

4.4.2 Public and Private Ownership

Total acreages of public and private land ownership in the Upper Gunnison and Uncompahgre Basins are shown in Table 4.9. Private lands with established public access for fishing are shown in Figure 4.7. Estimates of public and private stream miles for selected streams are presented in Table 4.10.

4.4.3 Existing Programs to Acquire Public Access

The CDOW has identified the acquisition of additional public access for fish and wildlife purposes as one of its highest priorities. Its program for opening up free public access to fishing through fish stocking agreements with private land owners is ongoing. The CDOW's program for leasing fishing easements according to stream classifications does not currently have any leases in force in the study area.

The USBR began its fish and wildlife mitigation for the Aspinall Unit of the Colorado River Storage Project in 1966. The fish and wildlife mitigation measures which have been completed to date are listed below:

1. 1966-1970 - Land acquisition (240 acres) and construction of Dome Lakes
2. 1968 - Acquisition of Bechtold property (76 acres)
3. 1967-1978 - Funding of Gunnison River studies for Colorado Division of Wildlife
4. 1972-1975 - Fishing easements acquired above Blue Mesa with ice-flooding easements
5. 1978 - Acquisition of Allen property at North Fork confluence for access (172 acres)
6. 1978-1985 - Acquisition of 10,273 acres of big game range
7. 1983 - Construction of kokanee salmon trap at Blue Mesa tailrace
8. Establishment of 200 cfs minimum flow through Black Canyon; increased to 300 cfs in 1986

The following measures remain to be completed before the Aspinall Unit mitigation plan will be fulfilled.

1. Acquisition of approximately 26 miles of fishing easements (approximately 5 miles acquired to date)
2. Funding of wildlife development on acquired big game range

The USBR continues to seek funds to complete this mitigation plan that was started approximately 23 years ago. The measures are developed in cooperation with the CDOW and the USFWS.

Fish and Wildlife mitigation for the USBR's Ridgway Dam and Reservoir includes acquisition and development of Ridgway State Park, improvements to Chipeta Lake southeast of Montrose, and post construction habitat monitoring on the reservoir and downstream. No additional land acquisitions are planned at present.

Neither the BLM, the U.S. Forest Service, nor the National Park Service currently has any formal plans or funding to acquire additional public lands within the study area.

TABLE 4.1

Curecanti National Recreation Area
Visitor Use

	1982	1983	1984	1985	1986
Total Visits	994,265	1,050,217	994,143	1,071,782	1,114,759
Total Visitor Hours	3,244,253	3,108,747	2,657,618	3,024,303	3,825,912
Special Uses					
Anglers	194,884	181,234	101,084	116,118	224,744
Boaters	133,529	128,707	69,568	67,758	165,294
Waterskiers	6,454	1,907	1,564	645	554
Swimmers	6,737	2,347	3,448	4,902	1,875
Picnickers	79,562	68,239	48,943	69,404	31,329
Camping	91,904	103,464	97,476	116,397	126,705
Windsurfers	N/A	N/A	N/A	1,373	1,879

TABLE 4.2

Black Canyon of the Gunnison National Monument
Visitor Use

Year	Total Visits
1977	310,467
1978	271,879
1979	234,286
1980	336,119
1981	266,604
1982	227,428
1983	291,618
1984	253,048
1985	266,012
1986	289,117

1977 - 1986 10-Year Average - 274,657

TABLE 4.3

Water-Based Campground Data for the USFS - Taylor River District

	Capacity	1986 RVD's
Eight campgrounds in lower 15 miles of Taylor River:		
Rivers End	15	5,467
Lakeview	35	16,940
Lottis Creek	23	7,298
Cold Spring	6	2,577
Lodgepole	16	7,053
Rosy Lane	20	8,413
One Mile	27	8,460
North Bank	17	3,292
Subtotal	159	59,500
Remainder of campgrounds in Taylor River District:		
Beaver Ponds	5	550
Lake Irwin	32	10,201
Gothic	4	1,614
Avery Peak	10	4,225
Cement Creek	13	4,642
Dorchester	10	2,470
Dinner Station	22	8,381
Mirror Lake	10	4,268
Mosca	16	2,756
Spring Creek	12	4,228
Almont	10	3,703
Commissary	7	2,107
Soap Creek	13	4,604
Subtotal	164	53,749
Total for Taylor River District	323	113,249

TABLE 4.4

Water-Based Campground Data for the USFS - Cebolla District

Campground Name	Capacity	1986 RVD's
Gold Creek	6	2,700
Spruce	9	1,700
Cebolla	5	1,000
Comanche	4	600
Deer Lakes	12	3,000
Big Blue	11	2,100
Middle Quartz	7	1,300
Pitkin	22	6,300
Quartz	10	2,800
William Creek	25	5,300
Snowblind	23	3,200
Hidden Valley	6	600
Total	140	30,600

TABLE 4.5

Water-Based Campground Data for the USFS - Ouray District

Capacity	1986	RVD's
Beaver Lake	11	3,679
Big Cimmaron	17	2,568
Silverjack	65	2,672
Total	93	8,919

TABLE 4.6

USFS Recreation Use
All Developed and Dispersed Activities
(RVD's)

	1983	1984	1985	1986
Taylor River District	578,300	565,100	617,700	619,700
Cebolla District	218,400	216,800	216,200	195,800
Ouray District	339,900	307,200	353,200	316,500
Total	1,136,600	1,089,100	1,187,100	1,132,000

TABLE 4.7

USFS Recreation Use - Water-Based Activities (RVD's)

	1986	1985	1984	1983
	Developed Recreation Sites Adjacent to Water			
Taylor River District	131,000	143,600	134,400	114,400
Cebolla District	32,800	42,800	46,400	42,400
Ouray District	8,900	9,900	8,400	15,100
Subtotal	172,700	196,300	189,200	171,900
	Water-Based Dispersed Uses			
Taylor River District	176,300	169,100	166,700	129,800
Cebolla District	20,800	22,000	21,100	22,000
Ouray District	10,900	14,600	11,700	13,400
Subtotal	208,000	205,700	199,500	165,200
Total Water-Based Recreation Use	380,700	402,000	388,700	337,100
	Fishing Use			
Taylor River District	25,800	24,700	24,400	22,800
Cebolla District	17,500	18,600	17,600	18,400
Ouray District	10,900	14,600	11,700	13,400
Total Fishing Use	54,200	57,900	53,700	54,600

TABLE 4.8

Summary of Annual Recreation Use in the Upper Gunnison and Uncompahgre Basins for 1986

	All Recreational Activities	Water-Based Recreation Activities	Fishing
CDPOR (visitations)	103,000	103,000	8,700
CDOW	small	small	small
Hinsdale County-Lake San Cristobal (angler days)	N/A	N/A	12,000
National Park Service:			
Curecanti	1,115,000	1,000,000	225,000
Black Canyon (visitations)	289,000	small	small
BLM	835,000	154,000	63,000
USFS (RVD's) (RVD's)	1,132,000	380,700	54,200
Private Campgrounds (visitations)	62,200	N/A	nil
Whitewater Boating (included in USFS and BLM estimates above)	12,000	12,000	5,000

TABLE 4.9

Public and Private Land Ownership [1)]

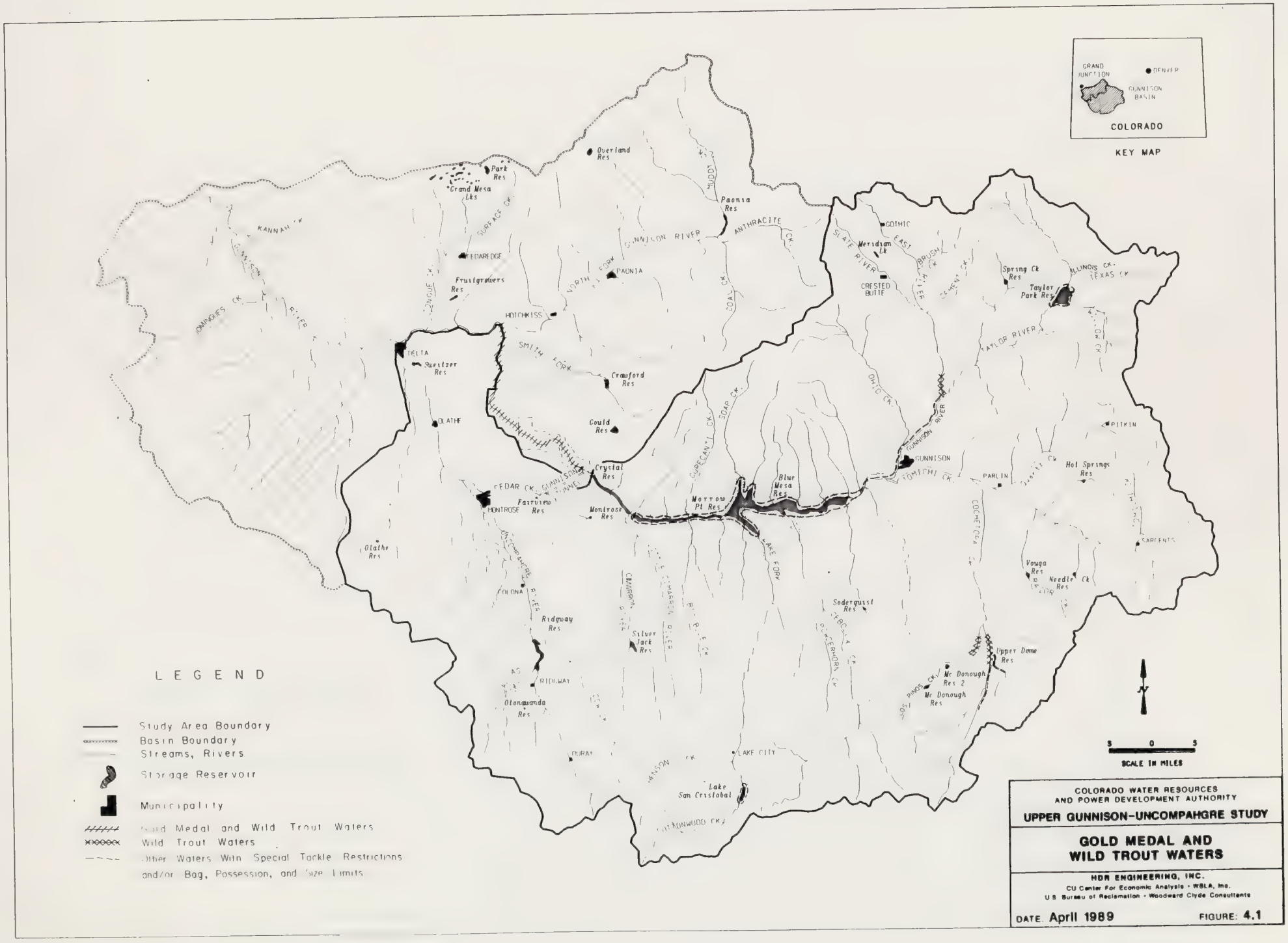
	Upper Gunnison Basin (acres)	Uncompahgre Basin (acres)	Total Study Area (acres)	(percent)
U.S. Forest Service	1,387,000	141,000	1,528,000	46.6
U.S. Bureau of Land Management	579,000	172,000	751,000	22.9
Curecanti Ntl. Recreation Area	42,000		42,000	1.3
State Lands and Parks	18,000	5,000	23,000	0.7
Division of Wildlife	18,000	6,000	24,000	0.7
Public Lands	2,044,000	324,000	2,368,000	72.2
Private Lands	486,000	422,000	908,000	27.8
Total	2,530,000	746,000	3,276,000	100.0

1) Acreage estimates adapted and updated to 1987 from Colorado Water Conservation Board, et al. (1962).

TABLE 4.10

Public Access Status on Streams in the Upper Gunnison and Uncompahgre Basins

Name of Stream	Miles on Open Public Land	Miles on Privately Controlled Land	Miles Under Fish Stocking Agreement	Miles Under Public Easement	Miles Access By Fee	Miles Leased by Clubs or Individuals	Total Miles Open to Free or Paid Public Access	Total Public and Private Stream Miles
Gunnison River (Almont to Blue Mesa Reservoir)	2.9	15.4	1.5	0.9	0.2	0	5.5	18.3
Ohio Creek (headwaters to confluence Gunnison River)	2.2	20.6	0	0	0	0	2.2	22.8
Slate River (confluence Poverty Gulch to confluence East River)	3.6	11.4	0	0	0	0	3.6	15.0
East River (headwaters to Almont)	12.3	18.2	0	0	0.4	5.0	17.7	30.5
Taylor River (Taylor Park Reservoir to Almont)	11.7	7.8	1.0	0	0	0	12.7	19.5
Taylor River (headwaters to Taylor Park Reservoir)	18.1	1.4	0	0	0	0	18.1	19.5
Texas Creek (wilderness boundary to Taylor River)	7	0	0	0	0	0	7.0	7.0
Willow Creek (confluence M&E Willow to Taylor Park Reservoir)	4.5	3.8	0	0	0	0	4.5	8.3
Tomichi Creek (headwaters to confluence Gunnison River)	5.8	48.2	0	0	0.4	3.0	9.2	54.0
Marshall Creek (headwaters to confluence Tomichi Creek)	6.0	7.0	0	0	0	0	6.0	13.0
Quartz Creek (confluence N&M Quartz to confluence Tomichi Creek)	2.0	14.5	0	0	0.8	0	2.8	16.5
Cochetopa Creek (confluence Pauline Creek to confluence Tomichi Creek)	6.6	22.9	5.0	4.3	0.3	0	16.2	29.5
Cebolla Creek (confluence E&W Fork to Blue Mesa Reservoir)	15.5	23.6	2.0	0	0	0	17.5	39.1
Lake Fork of the Gunnison River (Lake San Cristobal to Blue Mesa Reservoir)	7.6	23.7	0	3.5	0.1	1.0	12.2	31.3
Uncompahgre River (Ridgway Dam to Gunnison River)	1.0	45.0	0	0	0	0	1.0	46.0
Cow Creek (wilderness boundary to confluence Uncompahgre River)	4.8	10.2	0	0	0	0	4.8	15.0


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
Overland Res
Park Res
*Grand Mesa Lks
Paonia Res
GOTHIC
Meridian Lk
EAST
BRUSH CK
CEMENT CK
Spring Ck Res
ILLINOIS CK
TEXAS CK
Taylor Park Res
TAYLOR RIVER
CRESTED BUTTE
SLATE RIVER
ANTHRACITE CK
COAL CK
NORTH FORK GUNNISON RIVER
KANNAH CK
SURFACE CK
CEDAREDGE
Fruitgrowers Res
PAONIA
HOTCHKISS
TONGUE CK
DOMINGUES CK
SMITH FORK
DELTA
Suestzer Res
Crawford Res
OLATHE
Could Res
Crystal Res
CEDAR CK
GUNNISON TUNNEL
MONTROSE
Fairview Res
Montrose Res
Olathe Res
Morrow Pt Res
Blue Mesa Res
CURECANTI CK
SOAP CK
OHIO CK
GUNNISON RIVER
GUNNISON
TOMICHI CK
PARLIN
Hot Springs Res
PITKIN
CARBONATE CK
COCHETOPA CK
CARBONDALE
Vouga Res
Needle Ck Res
LAKE FORK
COLONA
UNCOMPAHGRE RIVER
Ridgway Res
Silver Jack Res
CRAWFORD CK
BLACK CANYON
Soderquist Res
ZERO-A CK
CEDAR CK
Upper Dome Res
Mc Donough Res 2
Mc Donough Res
LOS PINOS CK
RIDGWAY
Otonawanda Res
OURAY
LAKE CITY
HENSON CK
Lake San Cristobal
CUTTONWOOD CK
LEGEND
Study Area Boundary
Basin Boundary
Streams, Rivers
Storage Reservoir
Municipality
Gold Medal and Wild Trout Waters
Wild Trout Waters
Other Waters With Special Tackle Restrictions and/or Bag, Possession, and Size Limits
N
5 0 5
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
GOLD MEDAL AND WILD TROUT WATERS
HDR ENGINEERING, INC.
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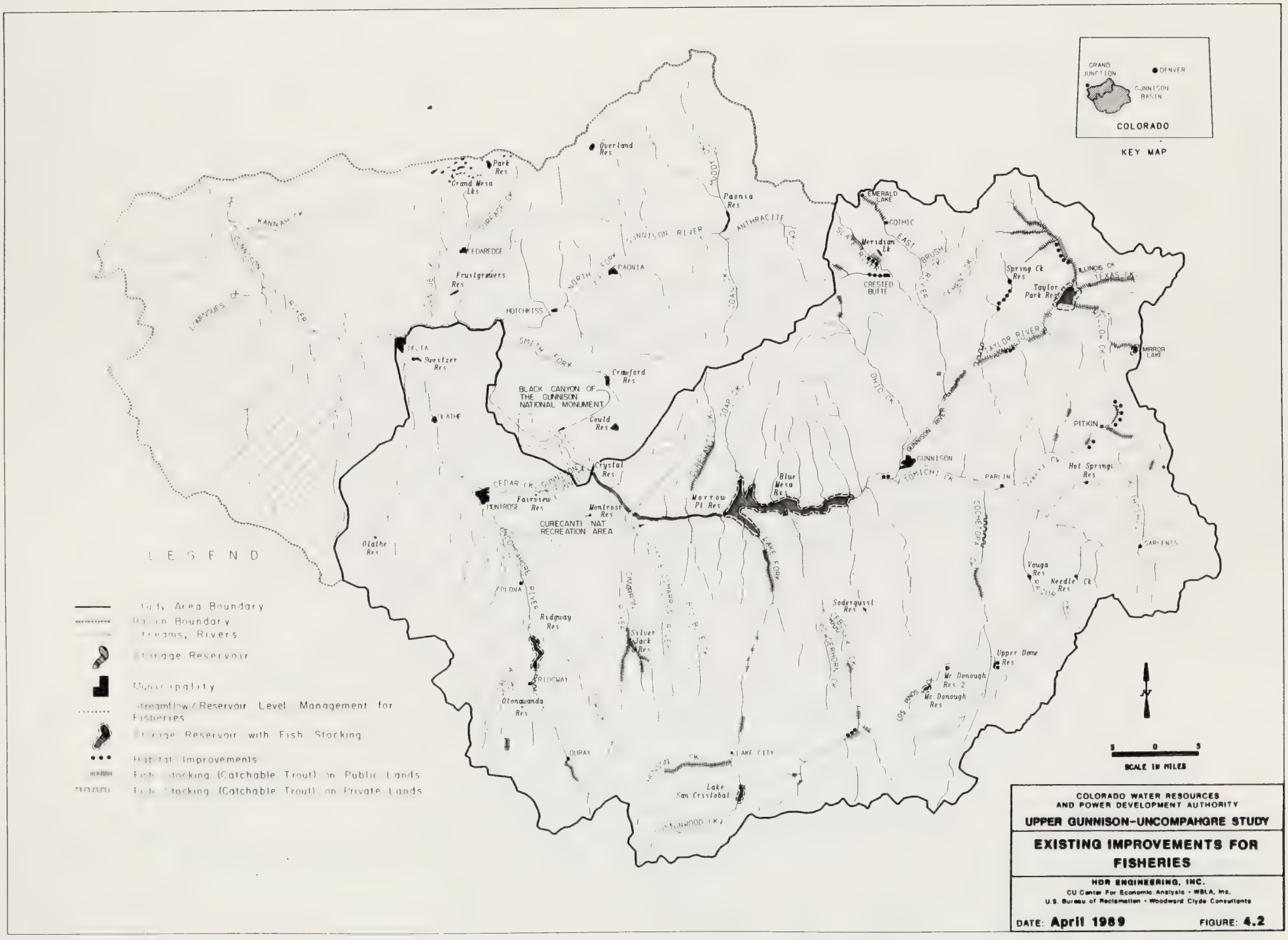
U.S. Bureau of Reclamation • Woodward Clyde Consultants
DATE: April 1989
FIGURE: 4.1


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
Overland Res
Park Res
Grand Mesa Lks
Paonia Res
EMERALD LAKE
GOTHIC
CRESTED BUTTE
Meridian Lk
Spring Ck Res
Taylor Park Res
MIRROR LAKE
EDAROEDGE
Fruitgrowers Res
PAONIA
HOTCHKISS
Sweitzer Res
Crawford Res
BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT
Could Res
CRYSTAL
Crystal Res
Fairview Res
MONTROSE
Montrose Res
CURECANTI NAT RECREATION AREA
Morrow Pt Res
Blue Mesa Res
GUNNISON
PITKIN
Hot Springs Res
PARLIN
SARGENTS
Vouga Res
Needle Ck Res
Olathe Res
OLATHE
Ridgway Res
RIDGWAY
Silver Jack Res
Sodergurst Res
Otonawanda Res
Upper Dome Res
Mc Donough Res 2
Mc Donough Res
OURAY
LAKE CITY
Lake San Cristobal
LEGEND
Study Area Boundary
Basin Boundary
Streams, Rivers
Storage Reservoir
Municipality
Streamflow/Reservoir Level Management for Fisheries
Storage Reservoir with Fish Stocking
Habitat Improvements
Fish Stocking (Catchable Trout) on Public Lands
Fish Stocking (Catchable Trout) on Private Lands
5 0 5
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
EXISTING IMPROVEMENTS FOR FISHERIES
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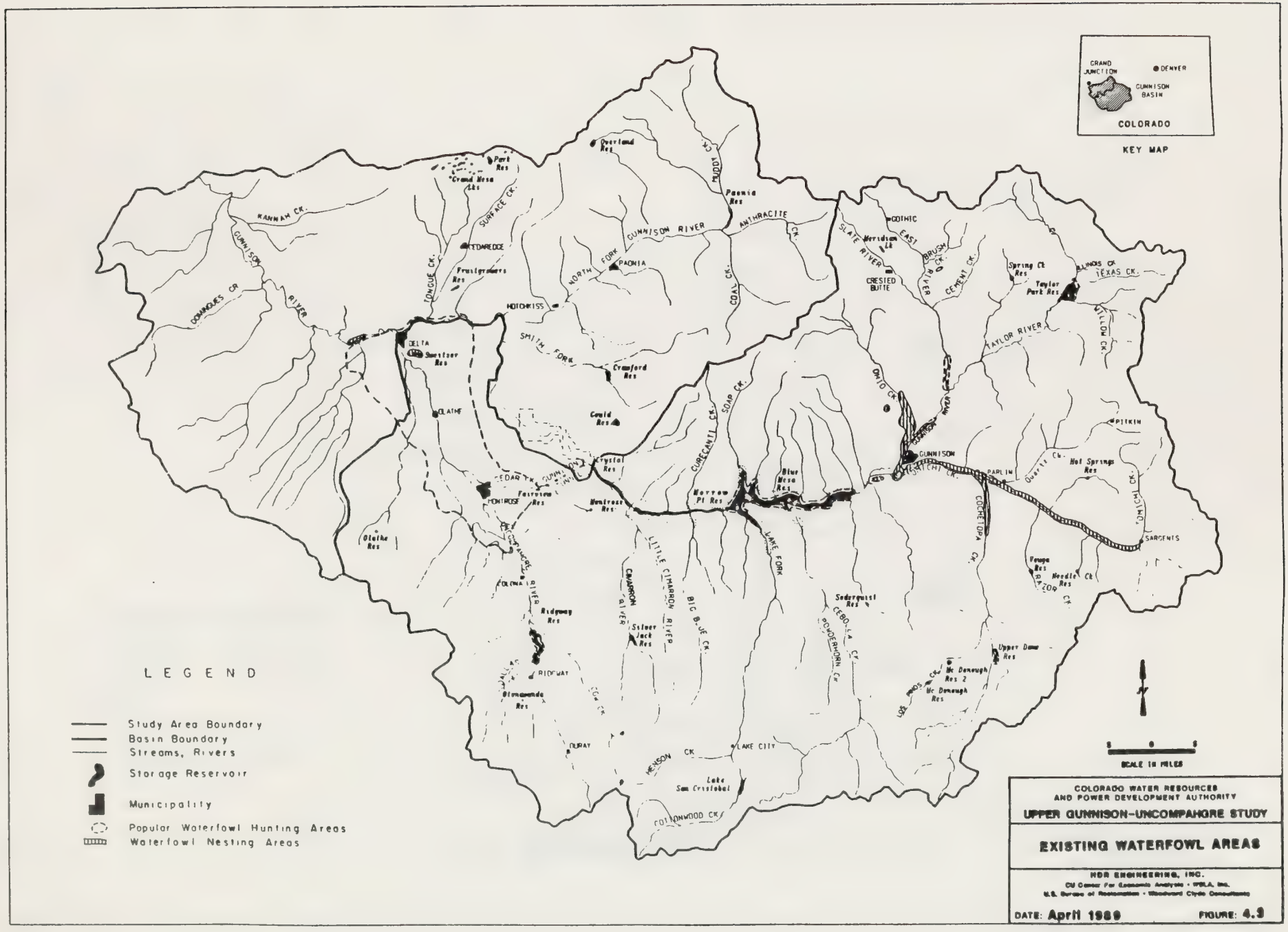
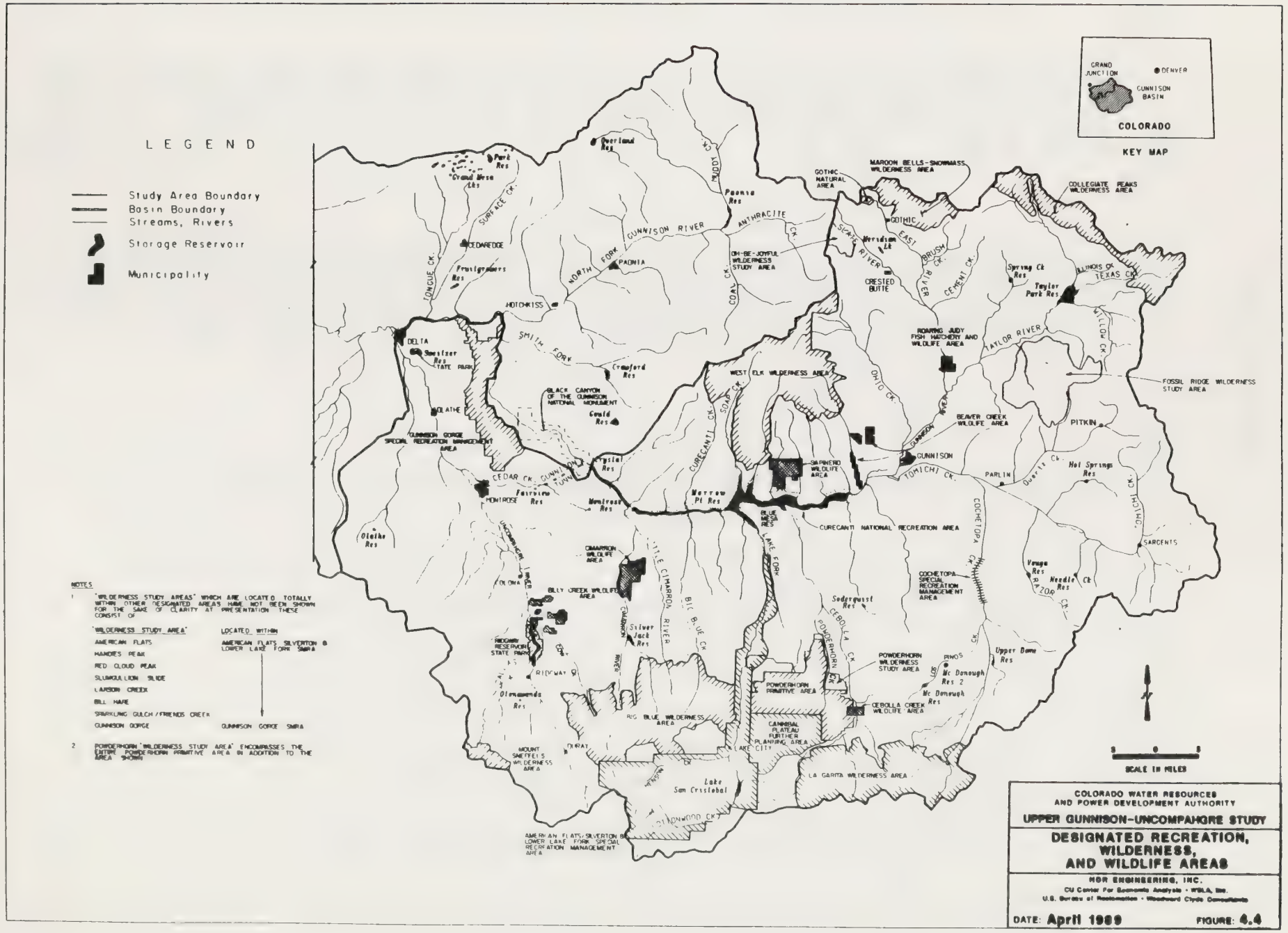
DATE: April 1989
FIGURE: 4.2


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
LEGEND
Study Area Boundary
Basin Boundary
Streams, Rivers
Storage Reservoir
Municipality
Popular Waterfowl Hunting Areas
Waterfowl Nesting Areas
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
EXISTING WATERFOWL AREAS
HDR ENGINEERING, INC.
DATE: April 1980
FIGURE: 4.3


LEGEND
Study Area Boundary
Basin Boundary
Streams, Rivers
Storage Reservoir
Municipality
GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
MAROON BELLS-SNOWMASS WILDERNESS AREA
GOTHIC NATURAL AREA
COLLEGIATE PEAKS WILDERNESS AREA
GOTHIC
CRESTED BUTTE
Meridian Lk
Spring Ck Res
Taylor Park Res
ILLINOIS CR
TEXAS CR
ROARING JUDY FISH HATCHERY AND WILDLIFE AREA
TAYLOR RIVER
FOSSIL RIDGE WILDERNESS STUDY AREA
BEAVER CREEK WILDLIFE AREA
PITKIN
GUNNISON
PARLIN
Hot Springs Res
SARGENTS
Paonia Res
Overland Res
Ford Res
Grand Mesa Lks
CEDAREDGE
Protectionists Res
HOTCHKISS
PAONIA
DELTA
Sweitzer Res STATE PARK
CLATHE
Crawford Res
Gould Res
BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT
GUNNISON GORGE SPECIAL RECREATION MANAGEMENT AREA
Crystal Res
Fairview
PONITROSE
Montrose Res
Olathe Res
CEDAR CK
SMITH FORK
NORTH FORK GUNNISON RIVER
SURFACE CK
TONGUE CK
MUDDY CK
ANTHRACITE CK
COAL CK
OH-BE-JOYFUL WILDERNESS STUDY AREA
WEST ELK WILDERNESS AREA
SOAP CK
CURECANTI CK
OHIO CK
SAPINERO WILDLIFE AREA
Morrow Pt Res
Blue Mesa Res
CURECANTI NATIONAL RECREATION AREA
COCHETOPA CK
TOMICHI CK
Quartz Ck
Vouga Res
Needle Ck
COCHETOPA SPECIAL RECREATION MANAGEMENT AREA
Soderquist Res
CHAMPION WILDLIFE AREA
BILLY CREEK WILDLIFE AREA
Silver Jack Res
LITTLE CIMARRON RIVER
BIG BLUE CK
CEBOLLA CK
POWDERHORN WILDERNESS STUDY AREA
POWDERHORN PRIMITIVE AREA
Mc Donough Res 2
Mc Donough Res
Upper Dome Res
CEBOLLA CREEK WILDLIFE AREA
RIDGWAY RESERVOIR STATE PARK
RIDGWAY
Ottoquenda Res
BIG BLUE WILDERNESS AREA
CANNIBAL PLATEAU FURTHER PLANNING AREA
LAKE CITY
MOUNT SNEFFELS WILDERNESS AREA
OURAY
Lake San Cristobal
LA GARITA WILDERNESS AREA
AMERICAN FLATS/SILVERTON & LOWER LAKE FORK SPECIAL RECREATION MANAGEMENT AREA
NOTES
1 'WILDERNESS STUDY AREAS' WHICH ARE LOCATED TOTALLY WITHIN OTHER DESIGNATED AREAS HAVE NOT BEEN SHOWN FOR THE SAKE OF CLARITY AT PRESENTATION THESE CONSIST OF
'WILDERNESS STUDY AREA' — LOCATED WITHIN
AMERICAN FLATS — AMERICAN FLATS SILVERTON & LOWER LAKE FORK SMRA
MANDIES PEAK
RED CLOUD PEAK
SLUMGULLION SLIDE
LARSON CREEK
BILL MAFE
SPARKLING GULCH / FRIENDS CREEK
GUNNISON GORGE — GUNNISON GORGE SMRA
2 POWDERHORN 'WILDERNESS STUDY AREA' ENCOMPASSES THE ENTIRE POWDERHORN PRIMITIVE AREA IN ADDITION TO THE AREA SHOWN
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
DESIGNATED RECREATION, WILDERNESS, AND WILDLIFE AREAS
HGR ENGINEERING, INC.
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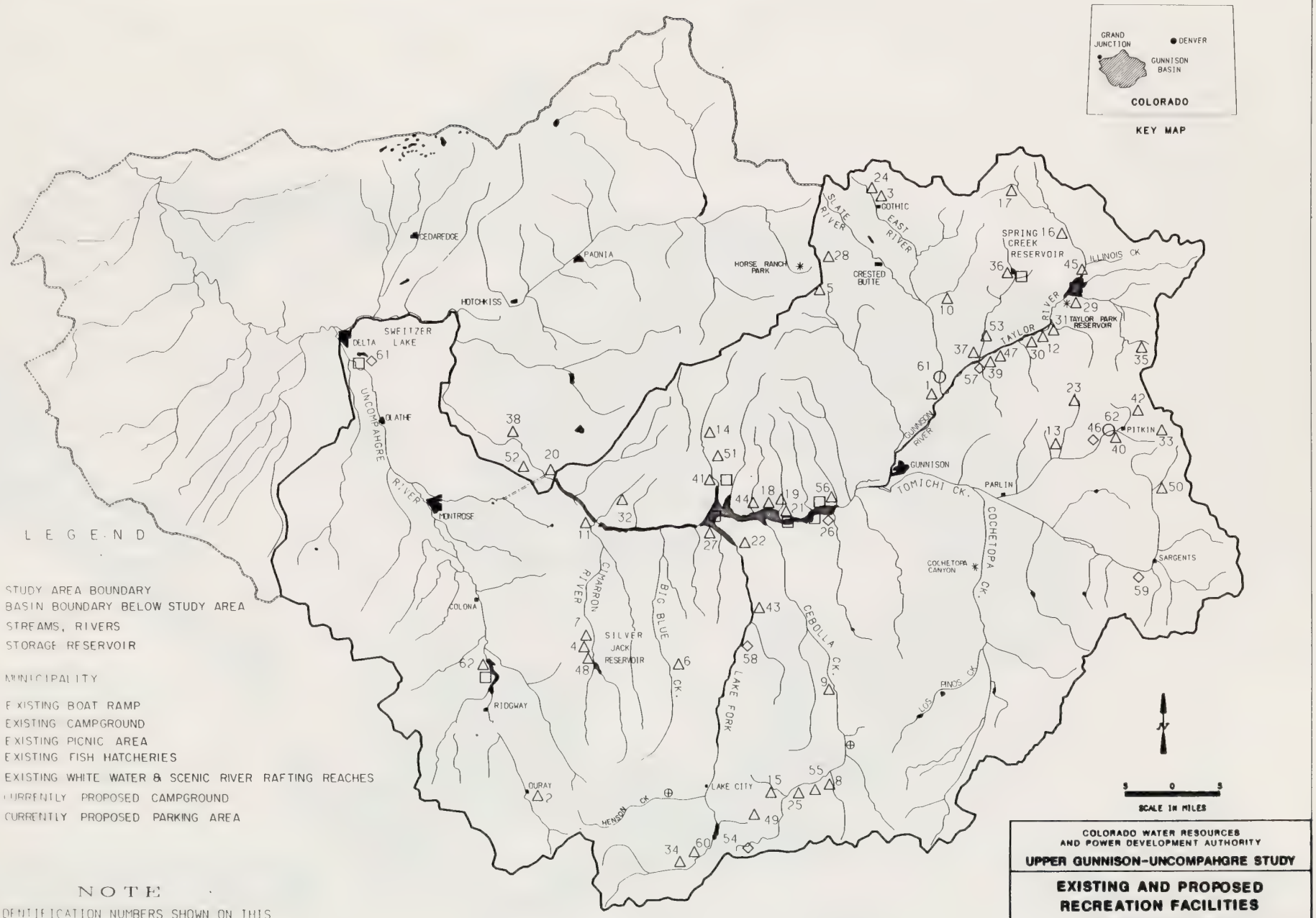
DATE: April 1989
FIGURE: 4.4

Existing Recreation Facilities

(Index for Figure 4.5)

MAP ID NUMBER	FACILITY NAME	GENERAL LOCATION	NUMBER OF SITES	CAMPING	PICNIC	BOAT RAMP	POTABLE WATER
1	ALMONT	ALMONT	10	X			X
2	AMPHITHEATRE	OURAY	30	X	X		X
3	AVERY PEAK	EAST RIVER	10	X			
4	BEAVER LAKE	SILVER JACK	11	X			X
5	BEAVER PONDS	OHIO CREEK	5	X			
6	BIG BLUE	BIG BLUE	15	X			
7	BIG CIMMARON	SILVER JACK	17	X			
8	CEBOLLA	CEBOLLA CR.	5	X			X
9	CEBOLLA CREEK	CEBOLLA CR.	5	X			
10	CEMENT CREEK	CEMENT CR.	13	X			X
11	CIMMARON	CURECANTI	25	X	X		X
12	COLD SPRING	TAYLOR RIVER	6	X			
13	COMANCHE	QUARTZ CR.	4	X			
14	COMMISARY	SOAP CR.	7	X			
15	DEER LAKES	CEBOLLA CR.	12	X			X
16	DINNER STATION	TAYLOR RIVER	22	X			X
17	DORCHESTER	TAYLOR RIVER	10	X			X
18	DRY GULCH	CURECANTI	10	X			X
19	EAST ELK CREEK	CURECANTI	20	X			X
20	EAST PORTAL	CURECANTI	17	X	X		X
21	ELK CREEK	CURECANTI	180	X	X	X	X
22	GATEVIEW	CURECANTI	7	X			X
23	GOLD CREEK	QUARTZ CR.	6	X			
24	GOTHIC	EAST RIVER	4	X			
25	HIDDEN VALLEY	CEBOLLA CR.	6	X			X
26	IOLA	CURECANTI	6		X	X	
27	LAKE FORK	CURECANTI	90	X		X	X
28	LAKE IRWIN	OHIO CREEK	32	X	X		
29	LAKEVIEW	TAYLOR PARK	35	X		X	X
30	LODGE POLE	TAYLOR RIVER	16	X			X
31	LOTTIS CREEK	TAYLOR RIVER	23	X			X
32	MESA CREEK	CURECANTI	5	X			
33	MIDDLE QUARTZ	QUARTZ CR.	7	X			
34	MILL CREEK	LAKE FORK	22	X			X
35	MIRROR LAKE	TAYLOR TRIB.	10	X			
36	MOSCA	SPRING CR. RESV.	16	X		X	X
37	NORTH BANK	TAYLOR RIVER	17	X			X
38	NORTH RIM	BLACK CANYON	13	X			X
39	ONEMILE	TAYLOR RIVER	27	X			X
40	PITKIN	QUARTZ CR.	22	X			X
41	PONDEROSA	CURECANTI	35	X		X	X
42	QUARTZ	QUARTZ CR.	10	X			X
43	RED BRIDGE	LAKE FORK	5	X			
44	RED CREEK	CURECANTI	7	X			X
62	RIDGEWAY RESERVOIR *	UNCOMPAHGRE	289	X	X	X	X
45	RIVERS END	TAYLOR RIVER	15	X			X
46	ROOSEVELT	QUARTZ CR.	-		X		
47	ROSY LANE	TAYLOR RIVER	20	X			X
48	SILVER JACK	SILVER JACK	65	X	X		X
49	SLUMGULLION	CEBOLLA CR.	18	X			X
50	SNOWBLIND	TOMICHI CR.	23	X			
51	SOAP CREEK	SOAP CR.	13	X			
52	SOUTH RIM	BLACK CANYON	102	X			X
54	SPRING CREEK	CEBOLLA CR.	6		X		
53	SPRING CREEK	TAYLOR RIVER	12	X			X
55	SPRUCE	CEBOLLA CR.	9	X			X
56	STEVENS CREEK	CURECANTI	55	X		X	X
61	SWEITZER LAKE	DELTA	-		X	X	X
57	TAYLOR CANYON	TAYLOR RIVER	5		X		
58	THE GATE	LAKE FORK	-		X		
59	TOMICHI CREEK	TOMICHI CR.	9		X		
60	WILLIAMS CREEK	LAKE FORK	25	X			X
63	ROARING JUDY HATCHERY	SLATE RIVER	-				
64	PITKIN HATCHERY	QUARTZ CR.	-				

* SCHEDULED FOR COMPLETION IN 1989



NOTE

IDENTIFICATION NUMBERS SHOWN ON THIS MAP ARE EXPLAINED ON THE FOLLOWING PAGE.

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

EXISTING AND PROPOSED RECREATION FACILITIES

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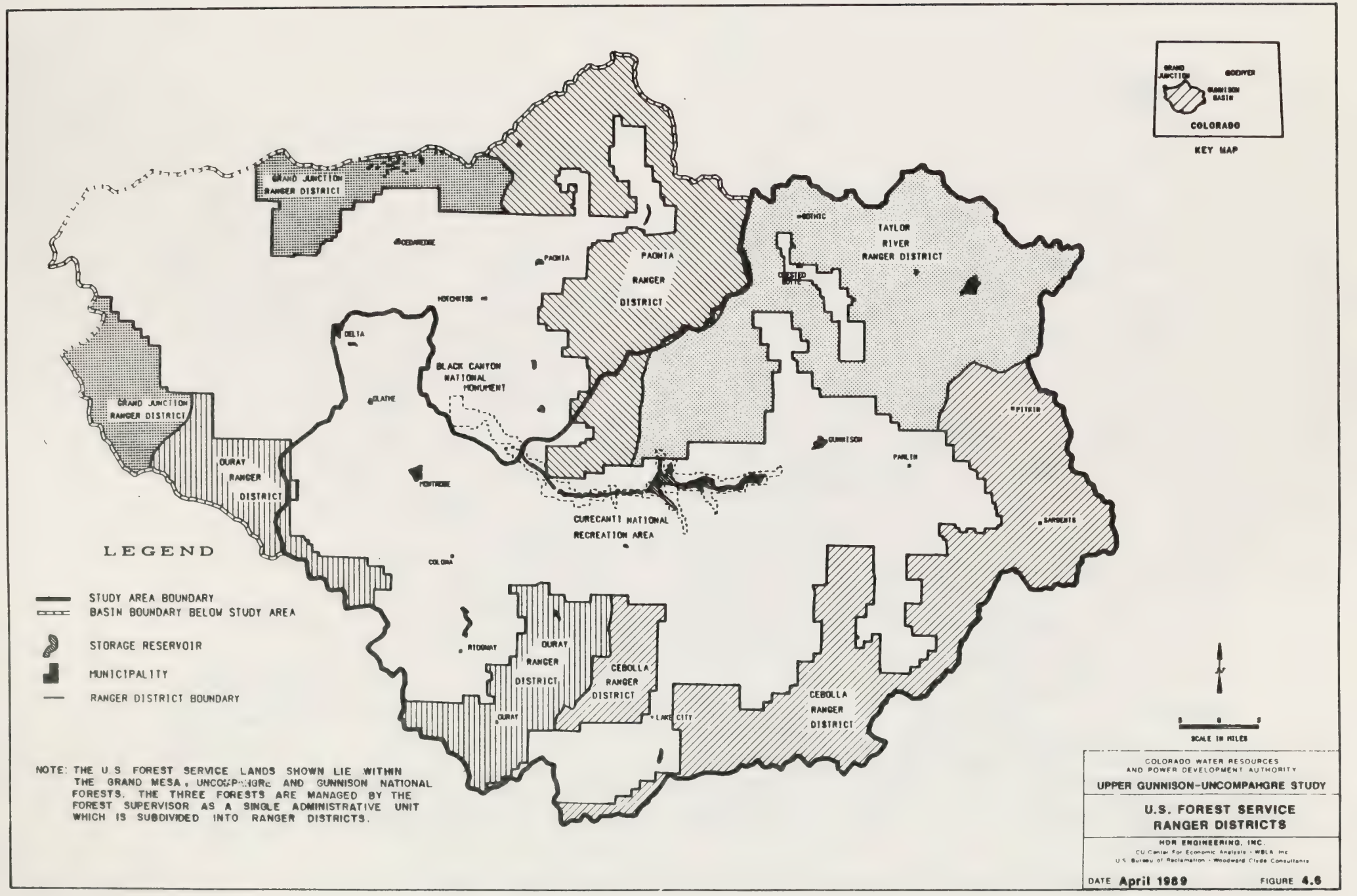
U.S. Bureau of Reclamation • Woodward Clyde Consultants

DATE: April 1989 FIGURE: 4.5



NOTE: THE U.S FOREST SERVICE LANDS SHOWN LIE WITHIN THE GRAND MESA, UNCOMPAHGRE AND GUNNISON NATIONAL FORESTS. THE THREE FORESTS ARE MANAGED BY THE FOREST SUPERVISOR AS A SINGLE ADMINISTRATIVE UNIT WHICH IS SUBDIVIDED INTO RANGER DISTRICTS.

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

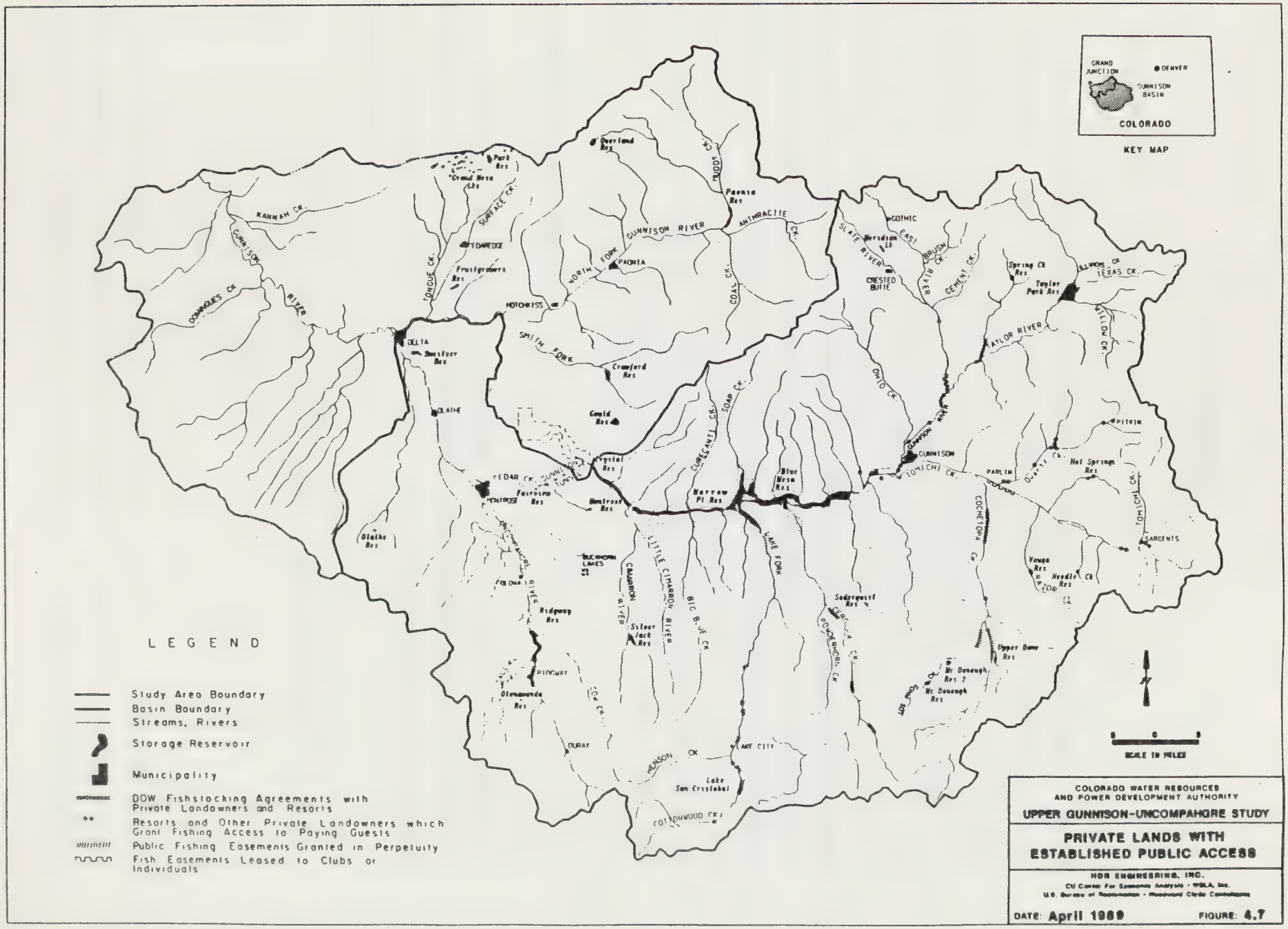
UPPER GUNNISON-UNCOMPAHGRE STUDY

U.S. FOREST SERVICE RANGER DISTRICTS

HDR ENGINEERING, INC.

CU Center For Economic Analysis - WBLA Inc
U.S. Bureau of Reclamation - Woodward Clyde Consultants

DATE April 1989 FIGURE 4.6


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
LEGEND
Study Area Boundary
Basin Boundary
Streams, Rivers
Storage Reservoir
Municipality
DOW Fishstocking Agreements with Private Landowners and Resorts
Resorts and Other Private Landowners which Grant Fishing Access to Paying Guests
Public Fishing Easements Granted in Perpetuity
Fish Easements Leased to Clubs or Individuals
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
PRIVATE LANDS WITH ESTABLISHED PUBLIC ACCESS
HDR ENGINEERING, INC.
CU Center For Economic Analysis · WSLA, Inc.
U.S. Bureau of Reclamation · Woodward Clyde Consultants
DATE: April 1989
FIGURE: 4.7

5.0 WATER RESOURCES

5.1 INTRODUCTION

The water supply within the Study Area originates mainly from snowmelt from the mountain peaks. The average annual discharge of the Gunnison River at the confluence of the Uncompahgre River is 2,065,000 af (sum of USGS gage Number 09149500, Uncompahgre River at Delta, Colorado and gage Number 09144250, Gunnison River at Delta, Colorado). The flow out of the Study Area is approximately 45 percent of the Colorado River Basin discharge at the stateline and about 21 percent of all surface runoff leaving the state. Approximately one-third of the Study Area discharge originates in the Upper Gunnison Basin above the confluence of the Gunnison River and Tomichi Creek. Groundwater supplies in the Study Area are estimated to be of negligible quantity and insignificant with regard to available water resources and potential water development. The remainder of this chapter discusses the selection of a hydrologic study period and the derivation of virgin flows used as input to a basin-wide hydrologic model.

5.2 HYDROLOGIC STUDY PERIOD

In planning water resource projects, it is customary to select a hydrological study period from the historical streamflow records for use in project simulation studies. The study period should have the following characteristics:

1. be statistically representative of the long-term period of record
2. include critical dry periods
3. start and end in wet years
4. consist of accurate data

It is important that the hydrologic characteristics of the study period be representative of historical basin hydrology in order to avoid incorrect conclusions as to the quantities of water available for potential development.

It is also important that the study period contain critical dry periods so that minimum yields can be estimated. If reservoirs are nearly full at the beginning and end of the study period, there is a greater assurance that estimated system yields will be more accurate. Finally, data quality and availability places some practical restrictions on the base period which can be used.

Annual flow records for three representative gages in the Study Area were reviewed to assess basin hydrologic characteristics. These gages were: 1) Taylor River at Almont (corrected for Taylor Park reservoir storage and release), 2) Lake Fork at Gateview (uncorrected), and 3) flow below Crystal (estimated virgin flows). Table 5.1 summarizes this review and compares the historical records from these three gages to the records for the proposed study period of 1953-1983.

Average flows for the proposed 1952-83 study period are slightly less than the period of record averages at the three sites. Statistically, the proposed study period provides a 95 percent confidence level. Flow variability is nearly identical in the period of record and the proposed base period at all three sites. With only one exception, the dry spells of duration five years or less all occur within the proposed study period. Based on these observations, the proposed study period exhibits the desired characteristics with respect to the selection criteria previously outlined and the period 1952-83 was selected for use as the hydrologic study period.

TABLE 5.1

Representative Streamflow Points
Flow Values in Acre-Feet

Parameter	Taylor River at Almont	Lake Fork at Gateview	Mainstem below Crystal
Period of Record	1911-1985	1938-1986	1906-1985
Average Annual Flow	246,000	174,600	1,344,800
Standard Deviation	69,300	54,000	408,200
Coeff. of Variation	0.2817	0.3093	0.3035
Proposed Study Period	1952-1983	1952-1983	1952-1983
Average Annual Flow	228,900	160,800	1,215,500
Standard Deviation	68,700	49,100	415,700
Coeff. of Variation	0.3001	0.3053	0.3419
Minimum Annual Flow	92,900 (1977)	64,300 (1977)	396,300 (1977)
Minimum 2-year Average	147,100 (1977-78)	93,400 (1976-77)	651,700 (1976-77)
Minimum 3-year Average	165,200 (1976-78)	108,500 (1954-56)	801,800 (1954-56)
Minimum 5-year Average	178,700 (1974-78)	137,500 (1977-81)	945,100 (1931-35)

5.3 DEVELOPMENT OF INFLOWS

Historical inflows at various points in the Study Area, corrected for the effects of stream diversions and operation of storage reservoirs where applicable, were developed for use as input to the hydrologic/water rights simulation model. These inflows are of two general types: historical gaged flows and virgin inflows. Historical gaged flows were used to represent the inflows from some basin tributaries. These include the area of the Uncompahgre basin from above Ridgway Dam to the South Canal, and the gains to the Gunnison River from the North Fork of the Gunnison.

Virgin inflows derived for the remainder of the upper Gunnison and Uncompahgre basins were developed by adjusting gaged flows at 14 reference gaging stations to reflect historical irrigation depletions and other water management influences. The resulting virgin flows at the reference stations were subsequently distributed among smaller sub-basins and tributaries to obtain the virgin inflows used as model input.

5.3.1 Estimation of Historical Irrigation Depletions

Estimates of historical irrigation depletions were based on calculations of potential crop consumptive use and irrigated acreage. Files of total monthly consumptive use and total annual irrigated acreage above Crystal Dam were obtained from the Colorado River Simulation System (CRSS) database. Estimates of irrigated acreage in Gunnison County were obtained from previous studies of the upper basin (USBR, 1964, 1973) and from Soil Conservation Service ditch surveys (Danni, updated pubs.). Acreages for portions of the basin outside Gunnison County were obtained from Water Commissioners and the USBR.

Unit monthly irrigation consumptive use rates were derived from the CRSS database by dividing the monthly total irrigation consumptive use by the CRSS annual acreages. These unit rates were then adjusted to better

reflect typical patterns of stream depletions; stream depletion is a greater proportion of diversion in the spring and a lesser proportion in the fall due to soil moisture recharge and groundwater return flow. This adjustment was based on detailed analysis of diversions and return flows of seven representative ditches in the upper Gunnison basin. The resulting unit depletion rates were then multiplied by revised USBR and SCS acreage estimates to arrive at historical monthly irrigation depletions.

5.3.2 Virgin Flow Development

The first step in deriving monthly values for the virgin inflow points was to develop natural flow values for the reference, or "core," gaging stations listed in Table 5.2. These USGS gaging stations were selected based on length and consistency of record and on coverage of the basin. Their location in the basin is shown on Figure 5.2. Virgin flows for these stations were derived by adjusting gage records for the effects of irrigation depletions, reservoir storage and evaporation, transbasin diversion, bank storage, and, in some cases, by extension of record by correlation.

The monthly virgin flow values derived for the core stations were then used to create files representing the difference in flow between successive gages. These "difference files" represent the virgin flow gains in the intervening reaches. The occurrence of some negative values (more than could be explained as channel losses) in these difference files led to further adjustment of virgin flow estimates for the core stations.

The adjusted core station virgin flows were then used to develop disaggregated virgin inflow values for sub-basins and tributaries. This disaggregation was based on area proportioning and on elevation/yield curves developed for the core stations. Elevation/yield curves derived for Pleasant Valley Creek and Spring Creek in the Uncompahgre Valley were

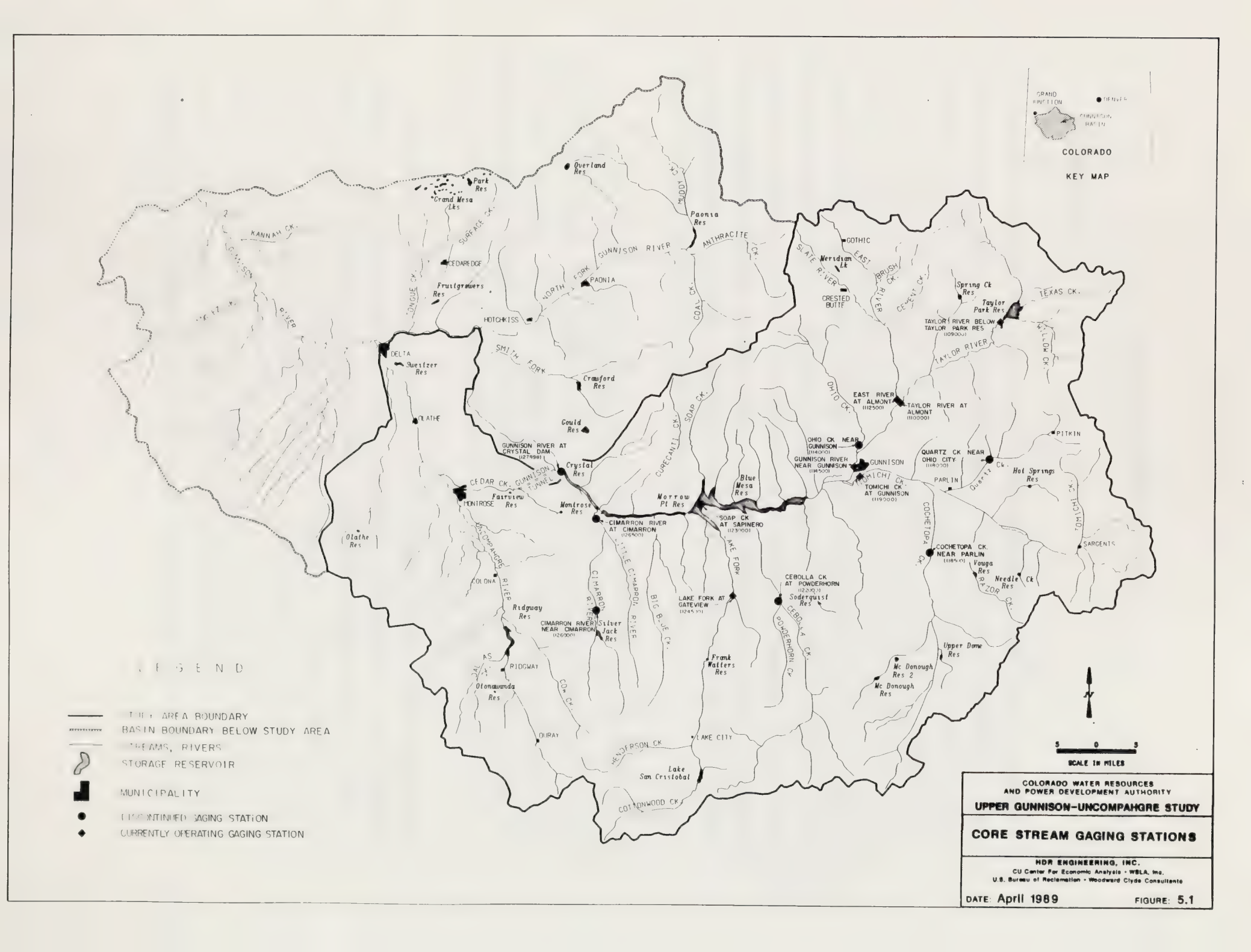
used to develop the remaining virgin inflow files for that part of the Study Area.

TABLE 5.2

Core Stations Used for Inflow File Development

Station Name	USGS Station Number	Corrections Applied[1] in Deriving Virgin Flows
Gunnison River at Crystal Dam	09127800	I,S,E,T,B,C
Cimarron River at Cimarron	09126500	I,S,T,C
Cimarron River near Cimarron	09126000	S,C
Lake Fork at Gateview	09124500	I
Soap Creek at Sapinero	09123000	I,C
Cebolla Creek at Powderhorn	09122000	I,T,C
Tomichi Creek at Gunnison	09119000	I,T
Cochetopa Creek near Parlin	09118500	I,T,C
Quartz Creek near Ohio City	09118000	I,C
Gunnison River near Gunnison	09114500	I,S
Ohio Creek near Gunnison	09114000	I,C
East River at Almont	09112500	I
Taylor River at Almont	09110000	S
Taylor River below Taylor Park Reservoir	09109000	S

(1) I=Irrigation depletions, S=reservoir storage, E=evaporation, T=transbasin diversion, C=extension by correlation, B=bank storage



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON–UNCOMPAHGRE STUDY

CORE STREAM GAGING STATIONS

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DATE: April 1989 FIGURE: 5.1

6.0 WATER RIGHTS CONSIDERATIONS

6.1 INTRODUCTION

Water resources in Colorado are administered by the State Engineer in accordance with water rights established under Colorado's doctrine of prior appropriation. Under this doctrine the first individual who puts a water source to beneficial use may establish the first (highest priority) right to the future use of the water from that source. Subsequent priorities for use of water from the same source then are established by the sequence of further appropriations. Water courts issue decrees which provide the legal right to divert and beneficially use water under a specific priority. Types of water rights include direct flow diversion rights, instream flow rights (non-consumptive), and storage rights. Tributary ground water (i.e., ground water connected to surface supplies) essentially is treated as surface water in terms of appropriation and adjudication.

The day-to-day administration of the water resources of the basin is the responsibility of the Water Commissioner for the Basin who reports to the Division Engineer. The Gunnison River Basin is included within Water Division 4. The Division Engineer reports directly to the State Engineer. The Gunnison Basin is subdivided into seven water districts as follows; 30, 40, 41, 42, 59, 62, and 68. These districts are shown on Figure 6.1.

The State Engineer is charged, under State statute, with facilitating "maximum water utilization." This is achieved through the use of certain administrative options that enable more beneficial water use than could be achieved under strict adherence to water right priorities. However, these options are employed in a manner such that adjudicated water rights are not injured. The key administrative options are "out-of-priority" storage and exchanges of water. Storing water out of priority maximizes use of the most efficient reservoirs by minimizing evaporation and seepage losses. Exchanges normally involve a downstream senior right holder using water stored in an

upstream junior right holder's reservoir while the junior right holder diverts water from the river that would otherwise be taken by the senior right holder.

Non-tributary ground water is also governed by state legislation. Laws governing ground water use are of relatively recent origin in Colorado. However, there are no designated non-tributary ground water aquifers of significant storage and suitable quality in the Study Area. Therefore, groundwater will not be discussed in this chapter.

The preceeding discussion indicates the importance of giving adequate consideration to senior water rights when planning new water development projects. The basin model developed and utilized in this study included water rights in order to ensure that project planning operation studies are performed in accordance with state water law. The remainder of this chapter presents a general discussion of the water rights situation in the Study Area while the following chapter discusses how water rights were treated in the model.

6.2 SOURCES OF WATER RIGHTS INFORMATION

Information pertaining to Gunnison River basin water rights was obtained from several sources. The primary source of information was the Water Rights Database maintained by the State Engineer's Office (SEO). Additional sources of information included the 1984 Stream Alpha List published by the SEO, interviews with, and line diagrams provided by the Division Engineer and District Water Commissioners in Water Division 4 (the Gunnison basin), numerous reports prepared for a variety of water resources studies in the basin, listings of instream flow decrees provided by the Colorado Water Conservation Board (CWCB), and review of individual decrees.

Sorted lists of water rights decrees were generated from the database files and subsequently reviewed with the respective Water Commissioners for each District in the Gunnison basin. Water rights were sorted by District and stream and listed in order of increasing Holt Number (from most senior to most

junior). Decrees which were shown as having been abandoned were deleted. The reallocation of decreed amounts through partial transfer and change in type of use and point of diversion was reviewed to ensure that double counting of decreed amounts was not occurring. Additional information obtained from Water Commissioners was used to further edit and refine the lists of decrees.

6.3 DIRECT DIVERSION AND STORAGE RIGHTS

Direct diversion decrees are water rights that allow the holder to divert the decreed amount of flow out of a stream for a stipulated beneficial use. There are more than 5000 direct diversion decrees that have been perfected and are presently in use in the Study Area. Practically all of these are for irrigation use but a few are for municipal use. The largest group of direct diversion decrees in the Study Area are associated with the Aspinall Unit hydroelectric facilities. The decreed capacities are: Blue Mesa, 3500 cfs; Morrow Point, 5450 cfs; and Crystal, 3000 cfs.

Storage decrees are water rights that allow the holder to take water from a stream and store it in a reservoir for discharge and use at a later time. The number of perfected storage decrees in the Study Area is small; however, the total volume is relatively large. The largest single perfected storage decree is the 952,000 af Blue Mesa Reservoir decree. The other major perfected storage decrees in the Study Area are also associated with Federal reclamation projects. The total active storage capacity of all the major reservoirs existing in the Study Area is approximately 1,060,000 af.

In addition to the perfected water rights in the Study Area, there are numerous conditional direct diversion and conditional storage decrees. The Gunnison River Basin is overappropriated. That is, there is not enough water on the average to simultaneously meet all the perfected and conditional decrees that have been issued in the basin. This is easily demonstrated by the fact that the total volume of storage decrees in the basin is several times the average annual discharge of the Gunnison River at its confluence with the Colorado River.

6.4 INSTREAM FLOW WATER RIGHTS

Instream flow water rights to protect the environment and to enhance recreational opportunities have become an important national issue which must be considered when planning water development projects. The existence of such water rights in the study area has been researched and it was found that several entities hold such water rights. These entities and their non-consumptive water uses are discussed below.

Included in the following discussion are two filings related to storing water in Taylor Park reservoir. Although not strictly instream flow filings, the intended purpose of the storage is to provide instream flow enhancement for fishery and recreation purposes.

6.4.1 Colorado Water Conservation Board Instream Flow Appropriations

The Colorado Water Conservation Board (CWCB) administers Colorado's Instream Flow/Natural Lake Level Program pursuant to Section 37-92-102(3) of the Colorado Revised Statutes. The CWCB is authorized to make applications in the Water Court for minimum streamflows and minimum lake levels which it determines to be sufficient to preserve the natural environment to a reasonable degree.

The CWCB presently holds or has applied for instream decrees on 180 stream reaches in the Gunnison River basin. Final notices were issued during 1987 for 11 additional stream reaches. The CWCB filings or decrees on major streams within the study area are summarized in Table 6.1. For streams where the CWCB has several filings or decrees on various reaches of a stream, only the largest is shown in the table.

6.4.2 Rocky Mountain Biological Laboratory Private Instream Flow Rights

The Rocky Mountain Biological Laboratory (RMBL) holds a group of nonconsumptive instream flow and minimum lake level rights upstream of Gothic in the East River and its tributaries. The CWCB also holds instream flow rights on some of the same stream reaches. The location and magnitude of the major RMBL nonconsumptive water rights are shown in Figure 6.2.

The rights were decreed absolute for general biological studies and research; for wildlife and fish culture procreation; and for recreation. The decrees acknowledge that the above activities "require the water entering and filling said run(s) to be and remain free of pollutants and undiminished in quantity and quality from its historic flow."

Appropriation dates for these water rights range between 1921 and 1927. The Copper Basin decrees were adjudicated in 1972. The East River and Rustler Gulch decrees were adjudicated in 1975.

6.4.3 Taylor River Basin Private Instream Flow Rights

The Taylor Park Pool Association (composed of local ranchers and landowners in the Taylor Park area) holds instream flow and minimum lake level rights on the Taylor River and its tributaries from Lottis Creek upstream. Applications for adjudication of these water rights were filed in 1973 and adjudicated in 1974 and 1975. The water rights were granted by the Water Court for recreation, wildlife procreation, fish culture, heritage preservation, and stockwater purposes with an appropriation date of June 1, 1910. These nonconsumptive rights are shown in Figure 6.3.

6.4.4 Taylor Reservoir Filings

In 1986 the Upper Gunnison River Water Conservancy District (UGRWCD) made two water rights filings in the Taylor River Drainage for the purpose of optimization of fisheries and recreation. In case No. 86CW202, the UGRWCD

applied for an absolute right for 111,260 af of storage in Taylor Reservoir and releases therefrom for fishery and other recreational uses in and below the reservoir area. The UGRWCD claims that the water in question was put to beneficial use on August 28, 1975, the date of the Taylor Park Reservoir Operation and Storage Exchange Agreement. By virtue of its 1986 filing date, the storage right would be junior to all water rights presently held by the United States for Taylor Reservoir.

In case No. 86CW203, the UGRWCD applied for a conditional decree in the amount of 61,530 af and an absolute decree in the amount of 44,700 af, granting the right to refill Taylor Park Reservoir. The UGRWCD claims that Taylor Park Reservoir has been in the past and would be refilled in the future after the United States has exercised its existing water right for the first filling of the reservoir. Beneficial uses described for the stored water and for releases made to the Taylor and Gunnison River include fish, wildlife, and recreational uses in addition to irrigation. The UGRWCD claims an appropriation date for the right to refill Taylor Park Reservoir of October 31, 1970.

6.4.5 Endangered Species Flow Rights

A requirement to maintain minimum instream flows in the Colorado River at Westwater Canyon has been proposed by the U.S. Fish and Wildlife Service (USFWS) for the protection of endangered species. Although the amount of that instream flow requirement at Westwater is still under study, a year-around minimum of 2000 cfs has been widely discussed.

The USFWS has proposed that Blue Mesa storage releases be made to partially support instream flow requirements in the Colorado River at Westwater Canyon. Releases would also be made from Green Mountain and Ruedi reservoirs, where a total pool of 5000 af has been set aside for this purpose. Another 5000 af will be supplied from these reservoirs by changes in present operational criteria which will release water in late summer that has historically been released during the winter months.

The USFWS is currently studying alternative operational scenarios using the HYDROSS model to better define augmentation requirements. Release schedules will then be negotiated with the USBR. The issue is complicated by the need to forecast future Upper Colorado River Basin water development, which could increase flow augmentation requirements. Such future development could result from growth in the Grand Junction area or from water development to serve the Denver Metro area.

6.4.6 Federal Reserved Water Rights

The concept of Federally reserved water rights dates back to the 1908 U.S. v. Winters case in which the Supreme Court held that reservation of public land by the Federal government implied an accompanying reservation of water. A number of subsequent decisions have reaffirmed and extended this doctrine to encompass all Federal reservations (National Forests, Monuments, Wilderness and Primitive Areas, Indian Reservations, etc.) and to provide for reservation of water "in sufficient quantity to satisfy the primary purposes of the reservation."

The McCarran Amendment in 1952 waived Federal sovereign immunity to state adjudications of water rights. Since then the Federal government has had to adjudicate reserved water rights through the various state procedures. Reservations made prior to the McCarran Amendment have priority dates the same as the land reservation. Federally reserved rights cannot be abandoned for any reason.

A large portion of the study area is owned by the Federal government. At this point in the study process, it does not appear that reserved water rights will impact development plans that will be considered by the study with the possible exception of the Black Canyon of the Gunnison minimum instream flow right which is discussed below.

A reserved instream flow water right was established in the Gunnison River as a result of the creation of the Black Canyon of the Gunnison National Monument by Presidential Proclamation in the years 1933, 1938 and 1939.

In 1971, the United States of America applied in Water District No. 4 for reserved water rights in the Gunnison River within the Black Canyon of the Gunnison National Monument. In 1972, this filing was combined with a large number of other similar filings associated with other Federal lands and reservations in Western Colorado. A water master was appointed by the Water Court in Division 5 to conduct a consolidated proceeding to receive evidence, adjudicate the Federal claims, and submit a report and proposed decree. The master referee's 1084 page final report was issued on August 6, 1976. On March 6, 1978, the Water Court adopted the majority of the master referee's recommendations including all of those made for the Black Canyon. The master referee's report included the recommendation that the United States be granted conditional water rights for instream flows in the Black Canyon of the Gunnison National Monument for fishery, recreational, scenic, and aesthetic purposes with the amount of such flows to be quantified within five years of the entering of the final decree. In 1979, the City and County of Denver, along with numerous other parties, appealed the rulings of the Water Court to the Colorado Supreme Court. In 1982, the Colorado Supreme Court upheld the right of the United States to possess a reserved water right for a Federal reservation in Colorado if it could be established that the specific purposes of the monument would be depleted without the claimed water. The Supreme Court limited the quantity of the reserved water rights to the minimum amount required to accomplish primary purposes of the reservations and remanded the case to the Water Court for litigation of the individual reserved water right claims. At present, the final decree for the Black Canyon of the Gunnison National Monument has yet to be entered and therefore the five-year time frame for quantifying that water right has not yet begun.

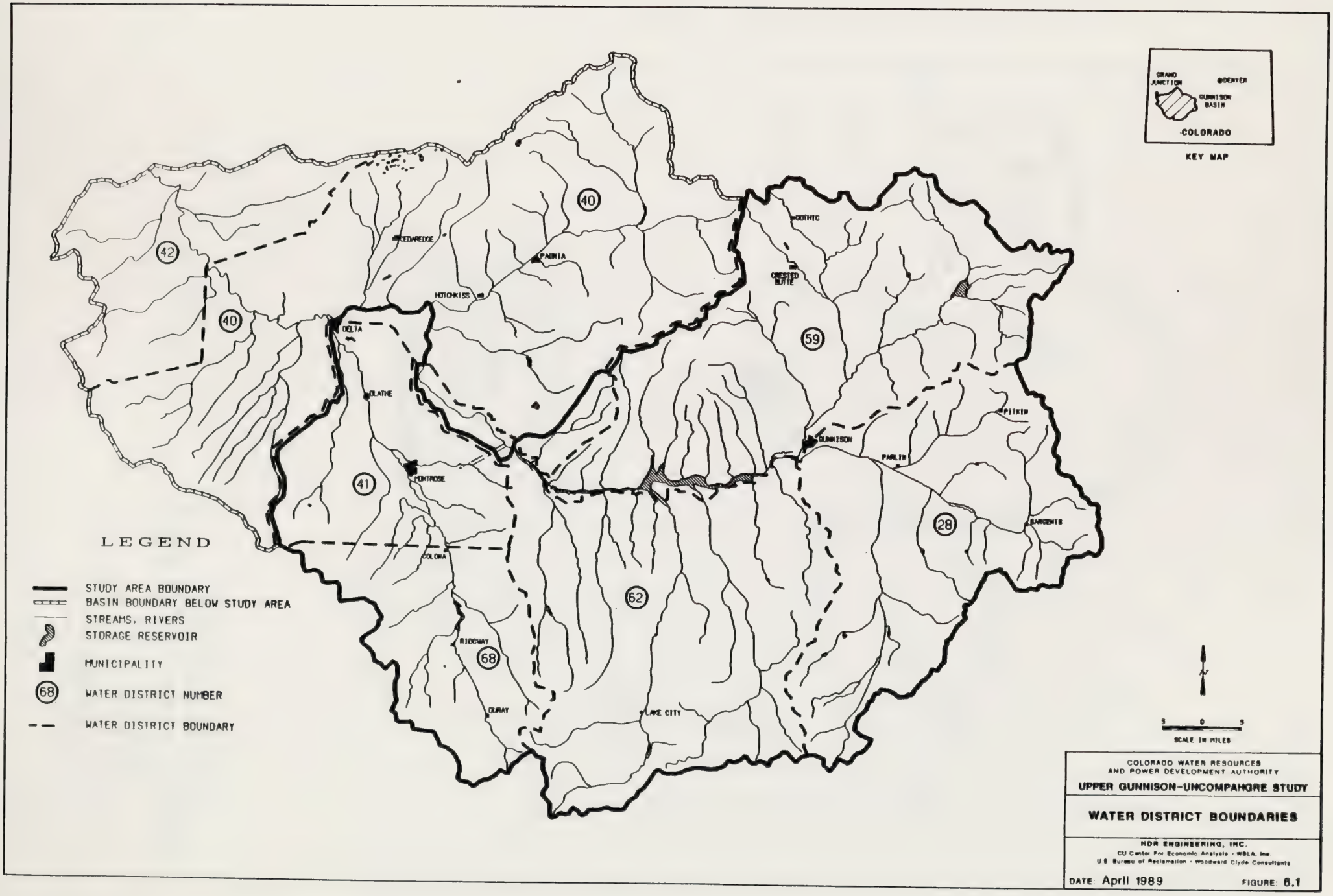
Legislation is currently proposed to create a national park surrounding the Black Canyon and to confer Wild and Scenic River status on the Gunnison River through the proposed park. Minimum instream flow quantities would be

established for the proposed Wild and Scenic River segment of the Gunnison. Under the auspices of the office of U.S. Congressman Ben Nighthorse Campbell and the Colorado Water Conservation Board, a technical working group has been established to develop criteria for wild and scenic instream flows. This working group, which includes fisheries, recreational, and other basin interests, has not yet defined an instream flow regime for the reach.

TABLE 6.1

Colorado Water Conservation Board Instream Flow Rights

	Summer	Winter
Cebolla Creek - confluence Powderhorn Creek to confluence Blue Mesa Reservoir	26 cfs	14 cfs
Cimarron River - confluence Fox Creek to confluence Little Cimarron	25 cfs	15 cfs
Cow Creek - confluence Wildhorse Creek to diversion near Forest Boundary	18 cfs	5 cfs
East River - confluence Alkali Creek to confluence Taylor River	50 cfs	27 cfs
Lake Fork of the Gunnison - confluence Henson Creek to confluence Blue Mesa Reservoir	45 cfs	25 cfs
Ohio Creek - confluence Mill Creek to confluence Gunnison River	12 cfs	12 cfs
Quartz Creek - confluence Gold Creek to confluence Tomichi Creek	12 cfs	12 cfs
Slate River - confluence Coal Creek to confluence East River	23 cfs	12 cfs
Taylor River - confluence Spring Creek to confluence East River	200 cfs	80 cfs
Tomichi Creek - confluence Marshall Creek to confluence Quartz Creek	18 cfs	18 cfs



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

WATER DISTRICT BOUNDARIES

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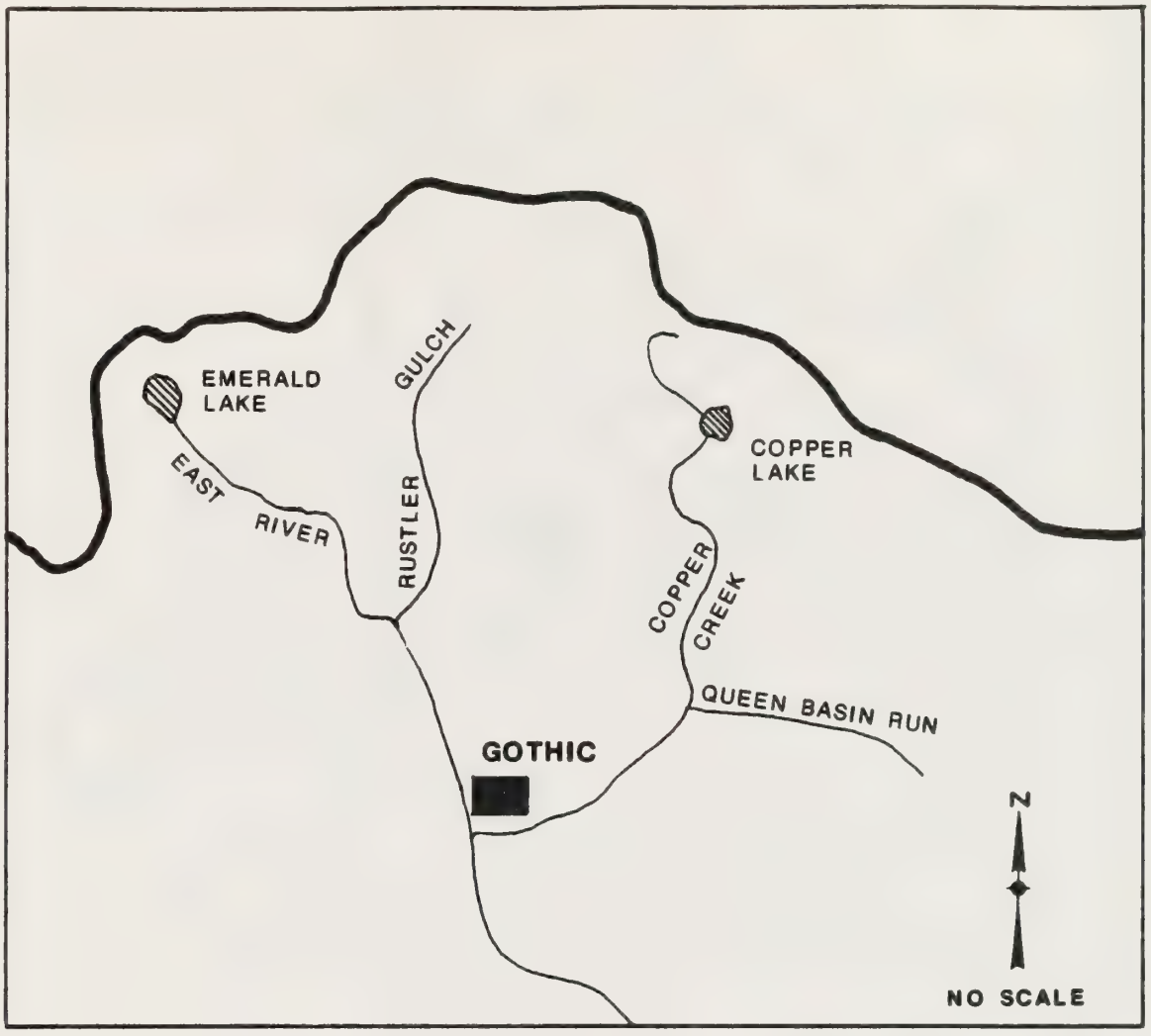
DATE: April 1989 FIGURE: 6.1



Tabulation of RMBL Instream Flow Rights

Queen Basin Run, at its confluence with Copper Creek	20 cfs
Copper Creek Laboratory, at the confluence of Copper Creek and the East River	90 cfs
Rustler Gulch Laboratory, at the confluence of Rustler Gulch with the East River	22.5 cfs
East River Laboratory, including the East River between Emerald Lake and Gothic	46 cfs
Copper Lake	578.51 af
Emerald Lake Laboratory	490.0 af

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

RMBL PRIVATE INSTREAM FLOW RIGHTS

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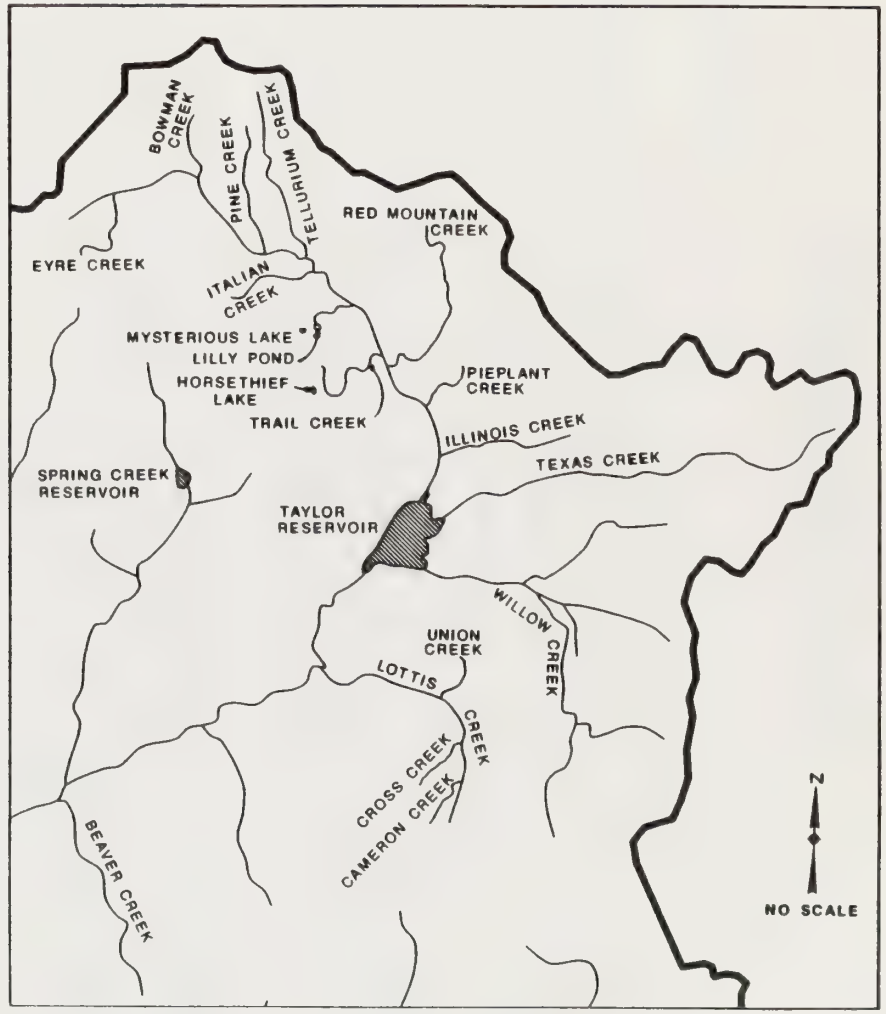
DATE: April 1989 FIGURE: 6.2

Taylor Park Private Instream Flow Rights
And 2nd Minimum Lake Levels

Illinois Creek	27.5 cfs
Texas Creek	150.0 cfs
Lottis Creek	60.0 cfs
Cross Creek	5.0 cfs
Cameron Creek	12.5 cfs
Union Creek	12.5 cfs
Pieplant Creek	15.0 cfs
Trail Creek	25.0 cfs
Red Mountain Creek	15.0 cfs
Italian Creek	75.0 cfs
Tellurium Creek	10.0 cfs
Pine Creek	10.0 cfs
Bowman Creek	12.5 cfs
Eyre Creek	15.0 cfs
Taylor River above Eyre Creek	20.0 cfs
Taylor River above the confluence with Lottis Creek	445.0 cfs
Taylor River below the confluence with Illinois Creek	225.0 cfs
Beaver Creek	20.0 cfs
Lily Pond	280.5 af
Mysterious Lake	403.5 af
Horsethief Lake	86.0 af



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

TAYLOR PARK PRIVATE WATER RIGHTS

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DATE April 1989 FIGURE 6.3

7.0 HYDROLOGIC/WATER RIGHTS MODEL

7.1 INTRODUCTION

The goal of the basin modeling effort was to develop a tool which would permit accurate and efficient preliminary evaluation of a variety of basin water management activities and development plans. As alternative water development plans are identified, their impact on hydrologic regimes of the basin must be assessed. The geographic size of the basin, the complexity of Colorado water law, and the sheer number of water development features that could be used as components of basin development plans made the use of a computer-based evaluation tool, or model, essential.

In order to achieve this overall modeling goal, the basin computer model needs to meet several objectives. These objectives are: 1) to simulate the hydrology of the basin, 2) to administer basin water rights under Colorado water law, 3) to represent operation of existing water development facilities in the basin, and 4) to allow rapid and convenient extraction of information. In addition, the model has to be flexible enough to easily incorporate proposed facilities and water rights while continuing to meet all of these objectives.

7.2 SCOPE AND SIMPLIFYING ASSUMPTIONS

Several simplifying assumptions were adopted in developing the hydrologic model. These assumptions and the resulting limitations to the model are discussed in general terms in this section and in more detail later in appropriate sections of this chapter.

A monthly time step was used in all basin model runs. While many basin water uses vary significantly on a daily basis, it was decided at the outset of the study that a monthly time step would sufficiently capture the seasonal variations in hydrology needed for a preliminary evaluation of basin water development needs and opportunities.

The North and Smith Forks of the Gunnison River were not modeled in detail but are represented in the model as inflows to the Gunnison mainstem. Gaged inflows from the North and Smith Forks and from Grand Mesa tributaries were assumed to adequately reflect water rights administration in those sub-basins. However, some major lower basin water rights (e.g., the Redlands Power Canal), as well as certain conditional water rights which could exert a call against upper Gunnison and Uncompahgre decrees, were represented in the basin model.

The smaller water rights in the basin were aggregated into priority classes. These classes were defined based on priorities of several major basin water rights which were modeled individually. The priority classification system was applied to the smaller rights and diversions occurring on each of the stream reaches in the basin. As a result, the many small water rights on any particular stream reach were represented as a more manageable group of aggregated water rights, each class in the group responding to river administration according to its relative priority.

The aggregated small water rights were modeled in terms of their historical depletions, i.e., the net of diversions and return flows. This reduced the need to analyze return flow patterns (most return flows from smaller irrigation rights accrue to the source stream quickly) except for major water users and for diversions from one sub-basin to another. Decreed amounts and historical diversions for the aggregated smaller rights were analyzed to ensure that the depletion patterns being used were reasonable in magnitude and timing and were assigned proper priorities.

7.3 MODELING METHODOLOGY

The basic modeling approach used in the basin study relied on a network optimizing code known as the Central Resource Allocation Model (CRAM). CRAM is a proprietary modeling system developed, with the exception of the core solution algorithm, by WBLA, Inc.

7.3.1 Network Optimization

A wide variety of resource allocation problems in which commodities must be moved from point to point (either spatially or temporally) can be visualized as networks. Commodities might be raw materials needed for industrial production or water needed to meet various demands. Typically, the movement of commodities in such problems is to be accomplished in such a way as to maximize value or minimize cost.

In general, network problems are structured as a system of "nodes" and "arcs." Nodes are points in time or space while the arcs connecting them represent pathways or processes through which commodities must flow. The flow along any arc may have a positive or negative unit cost or value associated with it. The solution of the network is the set of arc flows that produces the minimum total cost or maximum total value for the entire network.

In applying this approach to water rights in a river basin planning exercise, the value assigned to demand arcs typically reflect the water rights priority of that demand, senior rights having higher value. The network solution then becomes the resource allocation that most fully satisfies basin water rights in order of priority in the most efficient manner.

7.3.2 Central Resources Allocation Model

The Central Resource Allocation Model (CRAM) has been used in water supply planning, water rights analysis, and system operating studies in the past. It has been applied in a variety of situations having similar characteristics to the Gunnison River basin and was adopted for use in this study.

In a CRAM application, the basin streams, water rights, and water storage and conveyance facilities are represented as arcs in a network. Nodes serve simply as points to which arcs are connected. Each arc has several parameters associated with it, namely, a "from" node and a "to" node, a lower and an

upper bound on capacity (a lower bound capacity of zero is common), and a unit value or "rank." In the context of water allocation according to prior appropriation, the rank or value assigned to an arc reflects the water rights priority of the arc. The only arcs that are assigned a value or rank in a hydrologic network are demand arcs, arcs simulating stream reaches with instream flow decrees, and storage reservoirs.

The similarity in appearance between the physical pattern of streams and diversions in a river basin and the arcs and nodes of a network facilitate the description of a river basin in network terms. For example, a stream reach is usually represented as an arc with a zero capacity lower bound and an infinite (or very large) upper bound; rank for such an arc will be zero unless an instream flow water right exists in the reach in which case an appropriate rank will be assigned. A senior water right is represented as an arc having an upper bound equal to the decreed capacity (or the historic consumptive use) and having a high rank; such a right would be allocated water that is physically available before junior rights having lower ranges.

CRAM mathematically solves the network problem stated above using the Out-of-Kilter Algorithm (OKA). The OKA was developed in the early 1960's (Fulkerson, 1961) and has been subsequently refined and improved (Barr, et al, 1974). A detailed description of the procedure itself is beyond the scope of this report; however, very readable step-by-step discussions are available (Durban and Kroenka, 1967). The OKA was first broadly applied to the problem of allocating water supplies by the Texas Water Development Board in its SIMYLD model (1972) and extended in studies at Colorado State University where MODSIM and CONSIM were developed (Labadie, et al, 1982, 1984; Schafer, 1979). CRAM builds on this previous work, adding a number of modifications which increase the convenience of application and the speed at which results can be obtained.

In CRAM, the OKA is incorporated into a software system which allows the user considerable flexibility in problem formulation. This system includes auxiliary tools for creation of data files and extraction of summary output,

in addition to the core solution algorithm. Data can be written directly to Lotus 1-2-3 spreadsheets for post-processing or to word processors for inclusion in reports.

The CRAM system utilizes two time periods, a repeating period which contains one or more sub-periods. The repeating period might, for example, represent a year and the sub-period a month. This is the representation generally used in application of the system to the Gunnison basin. However, other interpretations of the two periods may be adopted so long as the input data and the periods are consistent.

7.4 GUNNISON RIVER BASIN NETWORK

The network model of the Gunnison River basin contains 152 nodes and 576 arcs. A diagram of the network is presented in Figure 7.1. Figure 7.1 is a schematic diagram, north is generally toward the top of the figure with flow moving westward, from right to left on the diagram. Appendix D presents a key to Figure 7.1.

Figure 7.2 is a basin map with several of the network node points marked on it. The purpose of Figure 7.2 is to assist the reader in orienting himself to and interpreting the network diagram.

The network has a form similar to the drainage pattern of the Gunnison River basin; the tributaries to the Upper Gunnison (e.g., Tomichi and Cochetopa Creeks, the East and Taylor Rivers) lie to the right in Figure 7.1, while the Uncompahgre River flows from the south at the lower end of the basin. The North Fork and Smith Fork have not been modeled in detail and are represented as sets of inflow and reservoir arcs between the Black Canyon and the confluence with the Uncompahgre. Virgin inflows at the upper ends of all tributaries, and natural flow gains at various points in the basin, are represented as inflow arcs.

Principal reservoirs and potential reservoir sites in the basin are shown as sets of arcs leading to and from the mass-balance node (labeled 0). The use of this mass-balance node is a modeling construct which permits end-of-month storage contents to be available for release or continued storage in the following month. Target storage volumes and priorities on storage arcs are varied from month to month in order to simulate reservoir operations.

Water rights in the basin are aggregated by priority class and, in most cases, represented as depletions (the net of diversions and return flows). These aggregated and prioritized depletions are shown in Figure 7.1 as demand arcs at various points in the basin. The use of aggregated depletions simplified the modeling process by reducing the total number of arcs required and by obviating the need to model return flow patterns of the many small irrigation diversions in the basin. Certain water rights for which diversions are totally consumptive to the basin of origin (e.g., the Gunnison Tunnel and the Cimarron Canal) were modeled as diversions with return flows occurring in the basin of use.

The following sections of this chapter describe the model development process in detail and present the basis for definition of the various arc parameters shown on Figure 7.1. Appendix D, which is a key to Figure 7.1, contains descriptions of all the arcs in the basin model network.

7.5 REPRESENTATION OF INFLOWS

The basin model contains 79 inflow points. Twenty of these inflows are return flows calculated internally by the model and the remaining 59 inflows are input to the model. The network diagram (Figure 7.1) shows these inflows as arcs leading into nodes and labeled "INFL XXX." Descriptions of each inflow arc, as well as all other arcs making up the model network, are contained in Appendix D.

The calculated inflows representing return flows from municipal and agricultural water use are located in the Uncompahgre Valley. The values of

these inflows are dependent on the specific level and type of water use. For example, INFL 62 represents a portion of the lagged groundwater return flow from land irrigated by the Ironstone Canal; the value of INFL 62 in any given month is a function of the amount of irrigation water applied to those lands in the six preceding months. The return flow points were identified based on detailed interviews with Water Commissioners and representatives of the UVWUA, the Bostwick Park Water Conservancy District, and the Project 7 Water Authority.

The inflows which are input to the model were developed as discussed previously in Chapter 5.0.

7.6 REPRESENTATION OF DIVERSION AND STORAGE WATER RIGHTS

The basin model was formulated to simulate the administration, under Colorado water law, of the decreed water rights in the Gunnison River basin. The vast majority of basin water rights are for relatively small diversions for irrigation on individual farms, and only a handful of major water rights in the basin exert the primary influence on river administration and the legal availability of water for new development. In light of this situation, the major water rights were modeled individually and smaller water rights were modeled in an aggregated form.

Certain conditional decrees and instream flow decrees were also represented in the basin model. Generally speaking, the conditional decrees represented are those judged as being representative of the overall level of development that may be compatible with the future demand forecasts discussed in the next chapter. Certain conditional decrees are also used in selected model runs to support proposed development plans. Instream flow decrees are represented only for those stream reaches which are subject to upstream depletions.

7.6.1 Select Water Rights Modeled Individually

Select water rights in the basin were modeled individually. Water rights were considered "select" depending on their size, relative priority, and location in the basin. In addition, certain water rights were modeled individually because they transfer water from one sub-basin to another; such diversions are, of course, totally consumptive to the sub-basin of origin.

The absolute water rights represented individually in the basin model are listed in Table 7.1. The table also provides descriptive information pertaining to each right, including the Holt Number associated with the water right. The Holt Numbers of the select water rights are important in the later aggregation of smaller irrigation decrees.

Direct flow rights were represented in the model as diversions and return flows. Cimarron Canal diversions are entirely consumptive to the Cimarron River and contribute return flows to the Gunnison River below the Black Canyon after irrigation use in the Bostwick Park area (some Cimarron diversions meet M&I demands via Project 7). The Gunnison Tunnel diversions are entirely consumptive to the Gunnison River above the Black Canyon and contribute return flows to the Uncompahgre River. Redlands Power Canal diversions are largely non-consumptive but are represented because they are a senior downstream call.

TABLE 7.1

Absolute Water Rights
Individually Represented in the Basin Model

Water Right	Holt Number	Decree Amount	Comment
Cimarron Canal #1	19499.00000	60 cfs	from Cimarron basin to Uncompahgre basin
Gunnison Tunnel Irrigation	20394.92081	1300 cfs	senior direct flow decree for the Uncompahgre Project
Cimarron Canal #2	20394.98926	39 cfs	from Cimarron basin to Uncompahgre basin
Redlands Power Canal	22284.91097	670 cfs	senior decree at confluence with Colorado R.
Cimarron Canal #3	28498.96656	86 cfs	from Cimarron basin to Uncompahgre basin
Taylor Park Storage	30668.6504	106,200 AF	senior storage decree for the Uncompahgre Project
Bostwick Park Project	38533.00000	14,000 AF	Silverjack reservoir releases to Cimarron Canal and Uncompahgre
Dallas Creek Project	39037.00000	varies	Project includes Ridgway reservoir and some conditional decrees
Blue Mesa Storage	40267.97842	952,202 AF	principal Aspinall Unit storage decree

Surface and groundwater return flows from select water rights diversions to irrigation use are computed internally in the model. Surface return flows are assumed to reach the stream in the same month in which they are diverted. Groundwater return flows are the result of ditch seepage and deep percolation during field application; in the model, groundwater return flows are lagged over a period of several months using factors derived from Glover Equation analyses. Return flow points are shown on the network diagram (Figure 7.1) as inflows; these inflow arcs are described in Appendix D.

Many return flows in the Uncompahgre project are intercepted and reused before they reach the river system. The allocation of intercepted return flows among the various project canals is based on detailed interviews with UVWUA personnel.

The operations of the select storage rights listed in Table 7.1 are also represented in the model. The operating procedures of the four reservoirs (Taylor Park, Silver Jack, Ridgway, and Blue Mesa) are discussed in detail in later sections of this chapter. Storage in Morrow Point and Crystal is not represented in the model because storage in these reservoirs does not change significantly on a monthly basis; they are used primarily for daily regulation of Blue Mesa releases.

An agreement between the USBR and the CWRCD and the file documents supporting the agreement obligate the USBR to allow junior, in-basin upstream appropriators the use of water in an amount not to exceed 60,000 af (U.S. Department of the Interior, 1984). This agreement is commonly referred to as the "Curecanti Subordination." The geographical distribution of the 60,000 af of depletions is as follows: 20,000 af in the drainage between Crystal and Blue Mesa Reservoirs and 40,000 af above Blue Mesa reservoir within the Gunnison River Basin. The current junior upstream depletions are far less than these amounts. Issues surrounding the implementation of the agreement and its administration have not yet been fully resolved. However, the issues do not affect the study's hydrologic modeling of the agreement including the modeling of historic Aspinall Unit operations.

The direct-flow water rights for the Aspinall Unit were not modeled individually. In the past, there has been no need for full administration of these direct-flow decrees against upstream junior in-basin appropriators because of the "Curecanti Subordination." Therefore, only the Aspinall Unit storage decrees were modeled so that the hydrologic modeling could be calibrated with historic operations. If a situation arises in the future where in-basin depletions junior to the Aspinall Unit water rights are greater than 60,000 af or out-of-basin diversions are implemented, the USBR may require administration of both the direct-flow and storage decrees. This study has not addressed specific impacts of such administration. The capacities of the Aspinall Unit direct flow decrees are listed in Section 6.3.

7.6.2 Aggregation of Smaller Water Rights

To simplify the basin model while accurately representing the administration of all water rights, the smaller water rights in the Gunnison basin were aggregated based on geographical proximity and on priority relative to the priorities of the select rights modeled individually.

Geographical aggregation simply reflects the physical proximity of the various small ditches and their location relative to tributary inflow points, reservoir sites, etc. For example, five aggregation points were defined for Ohio Creek; one of these represents ditches diverting directly from Mill Creek, while another represents ditches diverting below Castle Creek but above the proposed Price Reservoir site. Other aggregation points are similarly defined. A total of 54 aggregation points were defined in the basin model, representing 1314 individual ditches. Appendix C contains tables listing the ditches represented at each of these aggregation points and the decreed direct flow rights at each point. At each point, the aggregated decrees were subdivided into priority classes.

As described previously, in the computerized water rights database maintained by the State Engineer's Office (SEO), the relative priority of each decreed water right in the State is summarized in a parameter called the Holt

Number. The Holt Number of a water right is derived from the appropriation and adjudication dates of the right and is a unique number for each decreed right. Each newly decreed water right is given a Holt Number when it is entered into the database. The database is continually growing, thus the Holt Number corresponding to the most junior decree in the database is continually increasing.

The Holt Numbers of water rights in the Gunnison basin range from 9264.00000 (the most senior) to over 50000.00000 (the most junior). The water rights modeled individually defined four priority class intervals in this range of Holt Numbers. Smaller water rights having Holt Numbers falling into these intervals were then modeled in aggregated form. Table 7.2 lists the aggregation intervals used to model these smaller water rights.

It should be noted that priority class is independent of location and that water rights falling into each priority class will be found throughout the basin. The rights falling into a common priority class are affected in the same way by calls from senior decrees only to the extent that those rights have physical access to the same water. The model will not try to satisfy futile calls.

TABLE 7.2

Priority Class Intervals
Used for
Aggregation of Smaller Water Rights

Priority Class	Holt Number	Comment
Priority Class I	all < 20394.92081	all senior to Gunnison Tunnel irrigation decree
Priority Class II	all > 20394.92081 but < 30668.65040	junior to Tunnel but senior to Taylor Park
Priority Class III	all > 30668.6504 but < 40267.97842	junior to Taylor Park but senior to Blue Mesa
Priority Class IV	all > 40267.97842	junior to Blue Mesa(1)

(1) but possibly benefiting from Curecanti subordination

Note also that ranges of Holt Numbers included in some priority classes overlap the Holt Numbers of some select water rights. This means that the aggregated decrees which fall in the overlap range are not strictly administered. For example, the Willow Creek Ditch (5.21 cfs) has a Holt Number of 20394.80142 making it senior to the Gunnison Tunnel but junior to the first Cimarron Canal decree. In the model, the ditch falls into Priority Class I and will be represented as senior to <u>both</u> the Tunnel and the first Cimarron decree. The depletion attributable to the ditch is still incorporated into the model but it is assigned a priority not strictly in keeping with its decree.

Generally speaking, the decrees included in these overlap areas are relatively small and do not compete for the same physically available water. Thus the total stream depletion will seldom be affected by this approximation. The simplification substantially decreases model complexity with negligible effect on the accuracy of results.

The aggregated water rights in the priority classes listed above were represented in the basin model as demand arcs. The numerical unit values, or "ranks," assigned to those arcs maintained the priority ordering of the rights relative to the select water rights. The demand levels (upper bound capacities) assigned to the arcs reflected the stream depletions associated with the exercise of the water rights represented by the arcs.

7.6.3 Allocation of Depletions to Priority Classes

Generally speaking, the burdens placed on the Gunnison River basin hydrologic system by the exercise of the smaller water rights discussed above were modeled as depletions. Thus, it was necessary to estimate the stream depletions due to the exercise of aggregated rights at various locations throughout the basin and then to allocate the estimated depletion volumes into the various priority classes.

With certain notable exceptions, the lands irrigated by the smaller water rights are close to source streams; this means that irrigation water applied in excess of crop consumption returns to the stream system quite rapidly and in the same general area in which the water is diverted. The model was simplified substantially by representing water use for these irrigated areas as net depletions rather than diversions and return flows.

Historical and projected irrigation consumptive use values for each aggregation point in the basin were derived from climatic data and estimates of irrigated acreage. These consumptive use demands are described in some detail in Chapter 8.0. There is, however, a temporal difference between consumptive use and stream depletion. Depletion tends to exceed consumptive

use early in the season when the soil profile and groundwater reservoir are being recharged. Consumptive use tends to exceed depletion later in the season when groundwater is contributing maximum return flow. On an annual basis, consumptive use and depletion are approximately equal. The consumptive use estimates were adjusted, based on detailed operating studies of selected, representative ditches to better reflect stream depletion patterns.

The total monthly irrigation depletion at each aggregation point was then allocated between the four priority classes based on the distribution of water rights at that point and the historical diversions under the ditches at that point. Historical diversions were first allocated into priority classes by assuming that higher priority rights were used first. If diversions exceeded the total decreed amount for the higher priority class, remaining diversions were allocated to the next lower priority class until all diversions had been allocated. Depletions were then assigned to priority classes in proportion to this allocation of historical diversions.

Depletions are represented in the basin model as demand arcs. Demand arcs remove water from the network (there is generally no return flow associated with demand arcs). The network diagram (Figure 7.1) shows the various aggregation points in the basin where demand arcs occur (arcs labeled DEMN). In fact, there are four demand arcs at each of these aggregation sites, each arc representing the depletion associated with water rights falling into a certain priority class. Appendix D, the network key, provides a brief description of each demand arc.

7.6.4 Conditional Water Rights Decrees

A large number of conditional water rights decrees have been adjudicated in the Gunnison basin. It is reasonable to expect that some of these decrees will be perfected in the future but that others will not. It is difficult to predict with accuracy which of these decrees will be developed in the future and which ones will not. Based on the future water demand forecasts developed during the study, on discussions with members of the Technical Steering and

Advisory Committees, and on professional judgement, a list of conditional decrees to be included in the model was developed. Omission of conditional water rights from the list carries no legal implication regarding those rights. In fact, there are many reasons why a water supplier might legitimately maintain diligence on conditional water rights in excess of the decreed capacities included in this study's model. These reasons include but are not limited to the following:

- The water supplier may not have confidence in the reliability or longevity of its present water supply system and may be considering the implementation of a new type of system. Furthermore, it may be difficult to obtain changes in its present decrees to support the new system. An example would be the conversion of a groundwater system that is presently experiencing water quality or water table drawdown problems to a surface water storage system.

- The water supplier could have conditional decrees that may prove difficult to perfect for some reason but the possibility of transferring them to some other project appears feasible.

- The water supplier may have obtained conditional reservoir storage decrees in amounts greater than needed for their primary purpose of water supply in order to construct reservoirs large enough to allow other project purposes including reservoir recreation and enhancement of downstream flows.

- The water supplier may be anticipating a higher growth in water demand than was forecasted in this study. The forecasts prepared for this study are believed reasonable for the study area as a whole. There may be higher growth rates in individual areas, however, and local water suppliers are ultimately responsible for meeting those demands and may therefore choose to adopt more conservative approaches to meet future needs.

The major conditional decrees used in the basin model to support various proposed in-basin plan components are the Upper Gunnison Project and Dallas Creek Project decrees held by the Upper Gunnison Water Conservancy District (UGWCD) and the Tri-County Water Conservancy District (T-CWCD), respectively. These decrees were represented in some model runs and were absent from others, depending on the specific plan components being evaluated. The still conditional storage decree for Ridgway Reservoir is represented in all model runs.

Conditional decrees assumed to be developed "by others" are represented in all basin model runs. These are decrees which are assumed to be developed independent of any action on the part of study sponsors. Table 7.3 lists these independently developed conditional decrees.

TABLE 7.3

Conditional Decrees Operated in Basin Model
All Scenarios

Water Dist	Project/Decree Name	Source	Decreed Amount	Adjud. Date	Operated Amount[1]	Use Type
40	Snowshoe Dam	Anthracite Cr	75000 AF	08/11/69	61600 AF	Industrial
40	Lamm Reservoir	Gunnison	162700 AF	08/11/69	22000 AF	M & I
40	Paonia Refill	Muddy Cr	2576 AF	12/31/70	2756 AF	Irrigation
40	Fruitland Mesa Project	Crystal Cr	600 CFS	01/31/64[2]	50 CFS	Irrigation
41	Unc Valley Hydro	Gunnison	900 CFS	12/31/81	900 CFS	Commercial
			235 CFS	12/22/87[3]	235 CFS	
42	Grand Jct Pipeline	Gunnison	120 CFS	07/21/59	60 CFS	Municipal
59	City of Gunnison	Gunnison	10 CFS	06/20/57	10 CFS	
59	North Village Res	East River	700 AF	12/31/83[2]	700 AF	M & I
50	CB Mtn. Resort	East River	6 CFS	12/31/81[2]	6 CFS	Snowmaking

[1] typical monthly diversion and depletion patterns have been derived for each decree based on anticipated use

[2] benefits from Curecanti subordination

[3] application date, water right not yet adjudicated

Many of the decrees listed in Table 7.3 are assumed to be developed to something less than their fully decreed amounts. These assumptions, which are described in more detail below, are based on review of the decreed purposes, on discussions with members of the Technical Steering Committee, and on professional judgment. In no way should the assumption that a decree is developed to something less than its decreed amount be interpreted as abandonment of any portion of the decree. The decision to model these decrees in a less-than-fully-developed state is made for study purposes only and may not reflect the views of the decree holder.

The Grand Junction Pipeline decree is senior to Blue Mesa and to the Upper Gunnison Project conditional decrees. The total decree is for 120 cfs; at this time 18.6 cfs have been made absolute. For purposes of this study, an additional 41.4 cfs of the decree is assumed to be made absolute in order to supply future growth in the Grand Junction area, bringing the total made absolute to 60 cfs. Any additional development of the decree would imply growth far beyond present projections. In the basin model, the decree is assumed to divert water for direct use following a typical municipal demand pattern peaking at 60 cfs in mid-summer.

The Fruitland Mesa Project has a conditional decree to divert 600 cfs from the Crystal Creek basin for agricultural use in the Smith Fork basin. Based on recent evaluations of this project (PRC, 1980), only the Black Mesa Canal is assumed to be built. This project feature would divert water from tributaries of Crystal Creek at a maximum rate of 50 cfs. The Fruitland Mesa Project is assumed to benefit from the Curecanti subordination.

There are several conditional storage decrees in the North Fork basin for industrial use related to coal mining. For purposes of this study, half of the total amount of these decrees is assumed to be developed. The resulting 61,600 af of storage is further assumed to be located on lower Anthracite Creek at the Snowshoe Reservoir site. Water is assumed to be stored in priority during the runoff season and returned to the North Fork uniformly over the year.

The conditional decree for refill of Paonia Reservoir on the North Fork is assumed to be fully developed.

There are several storage decrees on the lower reaches of the Gunnison near the site of the proposed Dominguez Project. These include the decrees for the Austin and Lamm Reservoirs. During studies of the Dominguez Project, preliminary purchase contracts for 22,000 af of industrial water were negotiated. For purposes of the present study, this 22,000 af demand was assumed to be supported by transfer of the Lamm degree and exerted at the Dominguez site.

The UVWUA conditional hydropower decree for 900 cfs at the Gunnison Tunnel is assumed to be fully developed. In addition, the recent application for an additional 235 cfs, to bring hydropower flows up to Tunnel capacity, is also assumed to be developed. The desired pattern of Tunnel diversions reflecting hydropower project operations was obtained from the project developer.

The City of Gunnison holds a conditional direct flow decree for 10 cfs for municipal use under the O'Fallon Ditch. In the basin model, the consumptive use requirement projected for the City of Gunnison was assumed to be supported by perfection of this decree.

Two conditional decrees for water use at the Crested Butte Mountain Resort (CBMR) were assumed to be developed. CBMR holds these direct flow and storage decrees for domestic and snowmaking use. In the basin model, these decrees were represented as stream depletions; the net depletion pattern was derived from consideration of the seasonal pattern of snowmaking diversions and return flows and the municipal requirements created by a winter and summer resort area.

7.7 INSTREAM FLOW DECREES AND RELATED ISSUES

7.7.1 General Approach

There are several reaches of the Gunnison River and its tributaries for which instream flow regimes have been proposed or decreed, or for which there is significant interest in flow enhancement. There is also concern over instream flows for endangered species below the confluence of the Gunnison and the Colorado River. These instream flow issues fall generally into four categories: 1) instream flow decrees and recommendations of the Colorado Water Conservation Board (CWCB), 2) privately held instream flow decrees, 3) instream flows associated with the proposed designation of the Gunnison River through the Black Canyon as a wild and scenic river, and 4) instream flow goals as stated in the recovery plan for endangered fish species through Westwater Canyon on the Colorado River.

Instream flow decrees have mainly been issued on the smaller headwater streams in the basin. On many of these streams there are neither existing depletions nor proposed projects. In these cases instream flow decrees have not been modeled because flows in those stream reaches will simply be whatever occurs naturally. Only the instream flow decrees which are downstream of existing or proposed projects and depletions have been represented in the basin model.

The general procedure used to represent instream flow decrees in the basin model is to replace the single infinite capacity arc normally used to represent an uncontrolled stream reach with two parallel arcs. One of these arcs is assigned a positive unit flow value reflecting the relative priority of the instream flow decree and an upper bound reflecting the magnitude of the decree (this upper bound may change from month to month to reflect seasonally varying decrees). The other arc is left with infinite capacity and zero rank or value. The model tries to allocate water first to the arc having a positive value according to its basin priority up to the decree amount.

Excess flow in the reach, if any, is then carried in the other unconstrained arc. The total flow in the reach is the sum of flows in the two arcs.

Generally speaking, the instream flow decrees are among the most junior decrees in the basin. Their impact on water allocation is greatest on proposed projects for which senior conditional decrees have not already been obtained on newly contemplated upstream transfers or exchanges and on the very junior applications for out-of-basin diversions from the Taylor Park area.

7.7.2 CWCB Decrees and Recommendations

The Colorado Water Conservation Board (CWCB) presently holds or has applied for instream flow decrees on 180 stream reaches in the Gunnison Basin. Final Notices have been issued for 11 additional stream reaches. Not all the CWCB decrees, applications, and recommendations were included in the basin model. Many of them apply to headwater stream reaches which are not affected by current or contemplated water development. Some applications were omitted because their conditions are still uncertain; by the time these become final decrees their conditions may be substantially different from what is currently sought. Table 7.4 lists, in alphabetical order, the CWCB instream flow decrees and applications which were represented in the basin model.

TABLE 7.4

CWCB Instream Flow Decrees Represented in Basin Model

Stream Name	Reach Included	Model Link No.	Flow Rates, cfs[1]	Priority Group[2]
Brush Creek	M&E Brush to W Brush	55	8(sum), 5(win)	jr
	W Brush to Jarvis D	54	12(sum), 7(win)	jr
Castle Creek	N&S Castle to Acme D	45	7 year around	sr
Cebolla Creek	E&W Cebolla to Brush Cr	33	4 year around	sr
Cement Creek	hdwtrs to East River	56-58	10 year around	sr
Cimarron River	Fox Cr to L. Cimarron	22,23	25(sum),15(win)	jr
	L. Cim. to Gunnison R	24	16 year around	jr
Cochetopa Creek	Pauline Cr to Tomichi Cr	78-84	8.5 year around	jr
East River	Copper Cr to Brush Cr	233	25(sum),15(win)	jr
	Alkali Cr to Taylor R	48	50(sum),27(win)jr	
Lake Fork	Henson Cr to Blue Mesa	28-31	45(sum),25(win)	sr
Ohio Creek	Castle Cr to Mill Cr	41-44	10 year around	sr
	Mill Cr to Gunnison R	38,39	12 year around	sr
Quartz Creek	N&M Quartz to Gold Cr	90	10 year around	sr
	Gold Cr to Tomichi Cr	86-89	12 year around	sr
Slate River	Coal Cr to East River	51	23(sum),12(win)	sr
Soap Creek	W Soap Cr to Blue Mesa	125	12(sum),7(win)	jr
Taylor River	Illinois Cr to Taylor Res	63	55 year around	sr
	Taylor Res to Spring Cr	60	100(sum),50(win)	jr
	Spring Cr to East River	59	200(sum),80(win)	jr
Tomichi Creek	Triano Cr to Marshall Cr	77	9 year around	sr
	Marshall Cr to Quartz Cr	73-76	18 year around	sr

(1) definition of "summer" and "winter" is specific to each decree

(2) junior or senior to existing conditional decrees on same stream

7.7.3 Privately Held Decrees

There are several privately held instream flow decrees in the upper Gunnison basin. A few of these are in the headwaters of the East River near Gothic, but most are along the Taylor River and its tributaries above and below Taylor Park Reservoir.

The instream flow decrees near Gothic are held by the Rocky Mountain Biological Laboratory (RMBL). The RMBL also has several minimum lake level decrees for small ponds in the area. The RMBL decrees are upstream of any existing or proposed depletions and, therefore, are not represented in the basin model.

The Taylor River decrees were adjudicated in Division 4 Water Court in 1974 and 1975, and have an appropriation date of 1910. Several of the streams covered by these private decrees also have CWCB instream flow decrees for different flow amounts. The potential impact of these decrees is greatest on proposals for out-of-basin transfers from Taylor Park. The decrees having potential impact on future water development are listed in Table 7.5.

TABLE 7.5

Taylor River Privately Held Instream Flow Decrees
Potentially Affecting Previously Identified Projects

Stream Name and Reach	Decreed Flow (cfs)	Adjudication Date	Division 4 Case Number
Lottis Creek	60.0	10-15-74	W-1987
Illinois Creek	27.5	10-15-74	W-1985
Taylor River to confluence of Lottis Creek	445.0	1-21-75	W-1991

The legal status of privately held instream flow decrees is somewhat uncertain since C.R.S. 37-92-102(3) enacted in 1973 implies that only the State is empowered to appropriate water for instream flows. Furthermore, because the decrees are privately held, the possibility exists that they could be sold or abandoned. The legal rules for such sale or abandonment are not defined. Despite these uncertainties, it was decided that the privately held decrees should be represented in the basin model.

7.7.4 Black Canyon of the Gunnison National Monument

Proposed legislation to make the Black Canyon a National Park and to confer Wild and Scenic status on the river through the Park would provide for instream flows in the reach below the Gunnison Tunnel. Quantification of that flow is under study at present by a committee under the auspices of Congressman Ben Nighthorse Campbell and various proposals have been put forth by the committee members. In addition, the Nature Conservancy has proposed to donate a 300 cfs conditional water right to the CWCB to be used for instream flow purposes in that stream reach. Since the magnitude of this water right was not decided on at the time of model development, discussions were held with the Technical Steering Committee and the Advisory Committee and it was decided to adopt a year-round minimum flow of 300 cfs as the baseline instream flow regime for inclusion in the model.

Furthermore, it was decided that this minimum flow would be supported by releases from storage in Blue Mesa reservoir. The releases from the Blue Mesa Reservoir were modeled in a manner that the releases would meet both the senior Gunnison Tunnel decree requirements and the 300 cfs instream flows value as long as the Blue Mesa Reservoir level is above the minimum power pool. It was assumed that the releases would be made with a priority date equal to the conditional water right that the Nature Conservancy is presently (1988) negotiating to donate to the CWCB which is 1965. This assumption results in protecting the minimum streamflow release against potential diversions by downstream conditional water rights including the Mitex 1982 conditional hydropower decree.

This modeling assumption was selected for the following reasons: 1) it reflects the manner in which the river would actually be administered downstream of the Aspinall Unit in the absence of an agreement between competing water interests or a ruling permitting the Federal government to retain dominion over releases made for instream flow purposes; and 2) it quantifies the maximum effect such releases would have on Blue Mesa storage. It should be noted that this was a modeling assumption only and as such it has no legal implications. Resolution of this issue must be obtained outside of the study through appropriate negotiations and legal proceedings. The assumptions made in this study cannot be construed as being legally binding on any affected parties including the USBR, the UVWUA, the CWCB, or The Nature Conservancy.

7.7.5 Colorado River Endangered Species

The U.S. Fish and Wildlife Service (USFWS) is in the process, with the cooperation of a number of other entities, of addressing the flow requirements for endangered fish species in the Westwater Canyon area of the Colorado River downstream of its confluence with the Gunnison River. These flows are intended to be maintained primarily by releases from Green Mountain and Ruedi Reservoirs. Blue Mesa Reservoir is being discussed as an additional source of water if the supply from the other reservoirs is insufficient. Although the instream flow requirement at Westwater is still under study, a preliminary commitment to meeting a year-round minimum of 2000 cfs is indicated in the Recovery Implementation Program (USFWS, 1987).

The USFWS is currently studying this issue using the HYDROSS model to better define augmentation requirements. The issue is complicated by the need to project future upper Colorado basin development, for example, by the Denver Water Board and Aurora, which could increase flow augmentation requirements. Since this issue is still under study, and since it is not definite that the final determination will have an impact on the Gunnison Basin; this potential water demand was not modeled.

7.8 RELATIVE PRIORITIES OF MODELED WATER RIGHTS

Table 7.6 lists the relative priorities of the individual water rights, aggregated water rights, conditional decrees, and instream flow decrees as they are represented in the basin model. The rank assigned to each is the value placed on satisfying that decree in the model's water allocation algorithm. Thus decrees with larger ranks will, generally speaking, receive water before decrees with lower ranks. Only the relative size of the ranks is important for allocation purposes; the intervals between ranks are made unequal to permit more convenient modeling of nonconsumptive decrees, such as instream flow decrees, which do not remove water from the network.

TABLE 7.6

Water Rights Represented in Basin Model

Model Rank	Water Right or Priority Class	Holt Number	Comment
9500	Priority Class I	all < 20394.92081	aggregated small decrees
7000	Cimarron Canal 60 cfs	19499.00000	transbasin diversion
4300	Gunnison Tunnel	20394.92081	senior irrigation decree
4100	Cimarron Canal 39 cfs	20394.98926	transbasin diversion
4000	Redlands Power	22284.91097	senior downstream call
3800	Priority Class II	all > 20394.92081 but < 30668.6504	aggregated small decrees
3600	Cimarron Canal 86 cfs	28498.96656	transbasin diversion
3500	Taylor Park	30668.6504	major upstream storage
3300	Priority Class III	all > 30668.6504 but < 40267.97842	aggregated small decrees
2510	City of Gunnison	38285.00000	conditional decree
2500	Bostwick Park	38533.00000	transbasin diversion
2400	Dallas Creek	39037.00000	major upstream storage and conditional decrees
1900	Grand Junction Pipeline	39104.00000	conditional decree
1800	Upper Gunnison Project	39399.00000	conditional decrees
200	Blue Mesa	40267.97842	major basin storage
150	Group 1 Conditionals	all > 40267.97842 but < 47895.00000	Snowshoe, Lamm, Paonia, Fruitland Mesa(1)
100	Priority Class IV	all > 40267.97842	aggregated smaller decrees(1)
50	Senior Instream Flows	various	private and CWCB, including Black Canyon
40	Gunnison Tunnel Power	47895.00000	conditional decree
30	Group 2 Conditionals	all > 47895.00000	N. Village(1), CBMR(1),
20	Junior Instream Flows	various	CWCB
10	New Applications		e.g., basin exports

(1) benefits from Curecanti subordination

7.9 OPERATION OF EXISTING SYSTEMS

7.9.1 General

The major existing water storage and delivery systems in the upper Gunnison and Uncompahgre basins are explicitly represented in the basin model. These systems include the Aspinall Unit, the Uncompahgre Project (including Taylor Park Reservoir and the Taylor Park Exchange), the Dallas Creek Project, the Bostwick Park Project, and the Project 7 Water Authority. Diversions for irrigation purposes using direct flow water rights are generally represented in the basin model through the aggregation of water rights and depletions described previously.

The modeled operations of the major system are, to the greatest degree possible, reflective of current or anticipated operating rules and procedures. In certain cases, such as Aspinall operations, these procedures are well-defined and have been used for an extended period of time. In other cases, such as operation of Ridgway Reservoir, the procedures are still under development and can only be anticipated. In yet other cases, such as Taylor Park operations for instream flow enhancement, procedures are not well defined and vary somewhat from year to year.

Obviously, well-defined and strictly followed operating rules are easier to model than ad hoc decision-making. The operating procedures adopted for use in the basin model were derived from detailed interviews with officials of the USBR, the UVWUA, and the Bostwick Park Water Conservancy District and based on analysis of historical operating records, where they exist.

Operations are represented in the basin model through the use of special-purpose modules of computer code. These modules have been integrated into the general purpose code which makes up the CRAM modeling system. Generally speaking, these modules set the capacities and ranks of various arcs in the model network to encourage water allocation to storage, release, and diversion in keeping with specific operating rules and procedures.

A description of water rights, facility capacity, present operating policies, and a detailed description of how project operations are modeled is presented for each major existing system in Task Memorandum No. 5. Appendix E of this report presents an explanation of how reservoir inflow forecasts were derived and also defines the inflow forecast values used in the model.

7.9.2 Small Systems

There are numerous small water supply systems operating in the Gunnison basin. Most of these have annual demands of only a few hundred acre-feet and are not represented in the basin model. In these situations, stream depletions associated with municipal and domestic water use are assumed to be adequately represented by the aggregated depletions described previously in paragraph 7.6.2 or by the use of gaged rather than virgin inflows. For example, the Town of Ouray has a projected annual demand of just over 1000 af but is not represented explicitly in the basin model; future diversions to the Town are assumed to be adequately accounted for by using gaged rather than virgin inflows to Ridgway Reservoir.

Small systems which are represented explicitly include the City of Gunnison, the Town of Crested Butte, and Crested Butte Mountain Resort (CBMR). Because municipal demands produce immediate return flows, the demands of these small systems have been represented as depletions. The annual depletions projected for these systems were disaggregated into typical monthly municipal patterns. These monthly depletions were then assigned priorities based on the absolute and conditional decrees held by the various entities. Table 7.7 lists the annual depletion assumed for each of these small systems and the relative priority assigned to each. These demands are discussed in more detail in Chapter 8.

TABLE 7.7

Small M&I Systems Represented in the Basin Model

System	Annual Depletion	Model Rank
City of Gunnison	1210 af	2510
Town of Crested Butte	282 af	60
Crested Butte Mtn. Resort	302 af	30

7.10 MODEL CALIBRATION

7.10.1 General

In order to determine whether the basin hydrologic model functions correctly, that is, whether it properly allocates basin water supplies according to water rights and project operating rules, the model was subjected to a series of calibration runs. To perform these calibration runs, several indicators of basin hydrologic conditions were identified and a calibration period was selected. The historical values of these indicators over the calibration period were then compared to values predicted by the basin model for the same period.

Where discrepancies were noted, adjustments were made to model parameters to bring actual and predicted values into closer agreement. These adjustments were made primarily to parameters affecting the operating rules of various facilities and the return flow calculations for irrigated lands. Virgin inflows, water rights priorities, capacities of various facilities, and water demands were treated as givens and not adjusted to achieve model calibration.

It is a matter of judgment to decide when a model is "sufficiently" calibrated. Graphical comparison between historical and predicted values and calculation of correlation between historical and predicted values were both

used to judge the sufficiency of the calibration. The text which follows briefly describes the model calibration process and results.

7.10.2 Calibration Period and Performance Indicators

Because most of the water resources development in the Gunnison Basin is relatively recent, only the last few years of the 1952-83 study period are representative of current and near-term future basin conditions. Furthermore, systematic computerized records of water use for many portions of the basin exist only for recent years. These considerations led to the selection of the five-year period 1979-83 for model calibration.

The 1979-83 calibration period is appropriate for a number of reasons. First, the Taylor Park Exchange agreement was amended in 1979 to permit carryover of storage credits, thus providing additional flexibility in Taylor Park operations to meet instream flow objectives. Second, the Crystal Reservoir powerhouse did not go into full operation until 1976, so Aspinall Unit operations prior to that year are not representative. Third, computerized records of diversions for most basin water rights do not exist prior to 1979. Finally, the 1979-83 period contains a range of hydrologic conditions, including the dry year of 1981.

The indicators of model calibration used were monthly streamflow and end-of-month reservoir storage contents. Predicted streamflows were compared to gaged records at eight USGS gaging station locations in the basin. These stations were chosen so as to achieve a representative coverage of the basin.

In addition, the predicted end-of-month storage contents in Taylor Park and Blue Mesa Reservoirs were compared to actual values to permit calibration of reservoir operations.

Graphical comparisons between actual and predicted values were made for all calibration sites. Professional judgment was then used to ascertain the

causes of discrepancies between actual and predicted values and to determine which model parameters would be most likely to effect improvements.

Adjustments were then made to these parameters and the model was run again. This process was repeated until no further significant improvements could be made without making unreasonable assumptions about parameter values. In all, approximately 30 such model runs were made to achieve final calibration.

7.10.3 Results of Final Calibration Run

The results of the final model calibration run are summarized in Table 7.8. Generally speaking, the calibration is good. The sites having the lowest correlations between historical and modeled values are Taylor Park releases, and streamflow in the Uncompahgre River at Delta.

Correlations at the two Taylor Park sites are lower primarily because operating rules for Taylor Park Reservoir are not well defined. The reservoir forecasts used are relatively crude, being derived from Blue Mesa forecasts rather than specific conditions in the Taylor Park watershed. Furthermore, there are not hard and fast rules in place concerning fishery releases; these releases are still, in a sense, experimental, and decisions about release quantities are made by consensus between the USBR, the UVWUA, the UGWCD, and Division of Wildlife. In the model, operating rules are well defined and implemented consistently. It would be unrealistic to expect high correlations between the results of these rules and the result of the loosely structured decision-making process used historically.

Flows at the Uncompahgre River site near Delta are greatly influenced by the operation of Uncompahgre Project canals. The most ambiguous portions of that operation relate to the spatial allocation of intercepted surface return flows and the temporal and spatial allocations of groundwater return flows. The system characteristics represented in the model are based primarily on

judgments of UVWUA officials and Water Commissioners. All things considered, the correlation between historical and modeled flows at this site are good.

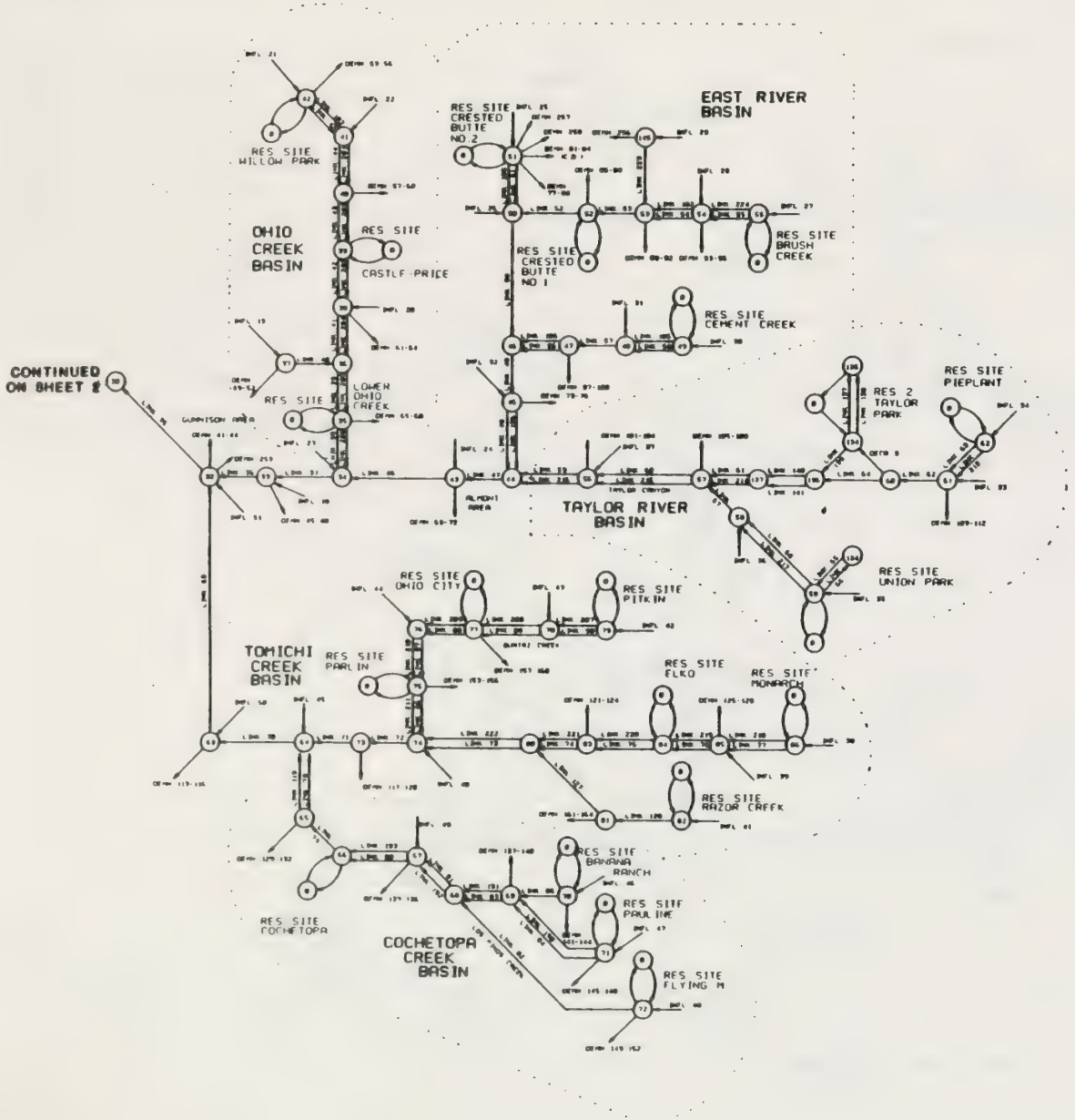
The good correlation between model results and actual Blue Mesa operations was achieved by imposing a minimum power release function which is dependent on reservoir storage. This function calls for a minimum release of 1250 cfs when reservoir live storage exceeds 390,000 af and a minimum release of zero when live storage is less than 200,000 af. Between 200,000 af and 390,000 af, the release is interpolated between 400 cfs and 550 cfs. The USBR has on occasion made informal power releases in this manner. Blue Mesa operational releases are generally determined from both reservoir storage level and predicted spring runoff with the ultimate objective of having Blue Mesa Reservoir fill in July.

TABLE 7.8

Results of Final Model Calibration Run

Calibration Site	USGS Gage Number	Model Link Number	Correlation(1) Coefficient
Taylor Park Reservoir Storage Contents	na	na	.88
Taylor River below Taylor Reservoir	09004500	61	.69
East River at Almont	09112500	48	.99
Gunnison River near Gunnison	09114500	36	.99
Tomichi Creek near Gunnison	09119000	69	.99
Blue Mesa Reservoir Storage Contents	na	na	.99
Cimarron River near Cimarron	09126000	22	.98
Gunnison River below Tunnel	09128000	7	.92
Gunnison River at Delta	09144250	6	.96
Uncompahgre River at Colona	09147500	96	.99
Uncompahgre River at Delta	09149500	125	.86
Gunnison River near Grand Junction	09152500	5	.98

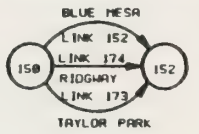
(1) Correlation Coefficient $r = \frac{Sxy}{Sx\ Sy}$



NOTES

1. MODEL SIZE: 576 ARCS, 152 NODES
2. KEY TO NETWORK DIAGRAM IS CONTAINED IN APPENDIX A OF TASK MEMORANDUM NO.5
3. 'INFL' = INFLOW
   'DEMN' = DEMAND
   'LINK' = REACH OR CONVEYANCE
   'DECR' = STORAGE DECREE
4. 'RES SITE' DENOTES POTENTIAL FACILITY BEING EVALUATED IN STUDY
5. 'RES 1' THROUGH 'RES 8' DENOTES EXISTING FACILITIES
6. . . . . DENOTES SUB-BASIN BOUNDARY

RESERVOIR FORECASTS



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

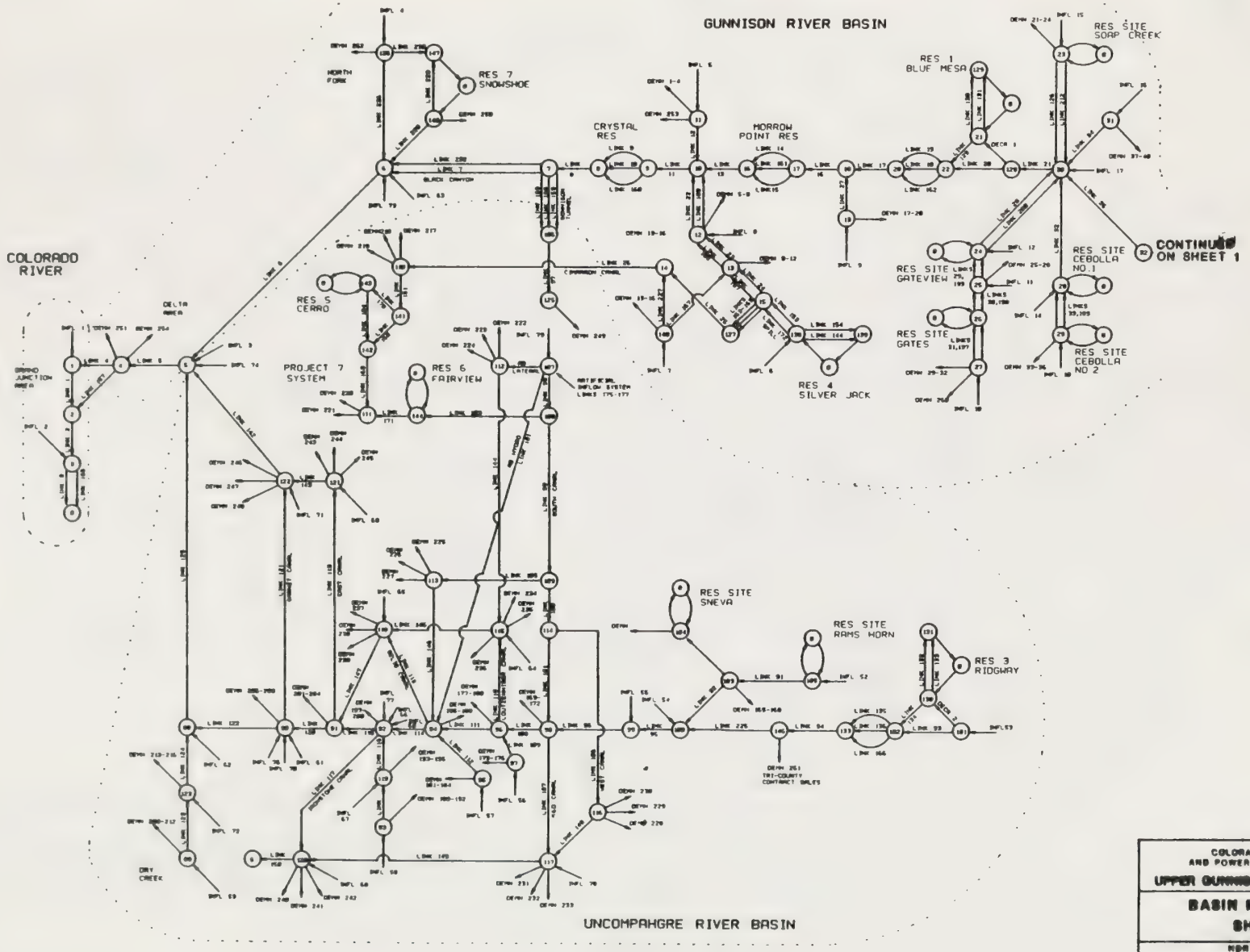
UPPER GUNNISON-UNCOMPAHGRE STUDY

BASIN MODEL NETWORK

SHEET 1 of 2

NBA ENGINEERING, INC.
CU Center For Economic Analysis · WRLA, Inc.
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE: April 1988 FIGURE: 7.1



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

BASIN MODEL NETWORK

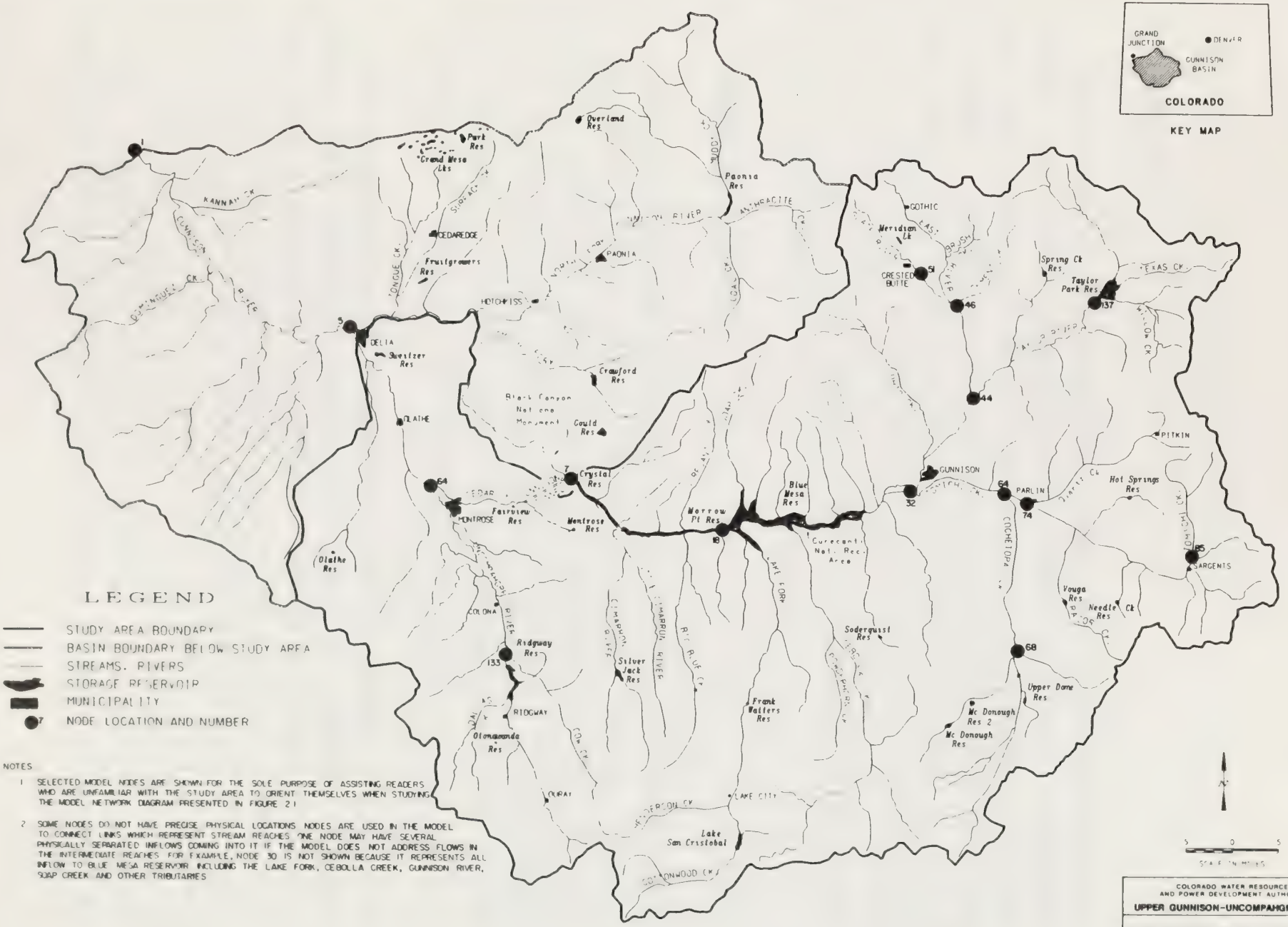
SHEET 2 of 2

HDR ENGINEERING, INC.

CU Center For Economic Analysis • YRSA, Inc.

U.S. Bureau of Reclamation • Woodward Clyde Consultants

DATE: April 1989 FIGURE: 7.1


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
LEGEND
STUDY AREA BOUNDARY
BASIN BOUNDARY BELOW STUDY AREA
STREAMS, RIVERS
STORAGE RESERVOIR
MUNICIPALITY
NODE LOCATION AND NUMBER
Park Res
Grand Mesa Lks
Overland Res
Paonia Res
CEDAREDGE
Fruitgrowers Res
PAONIA
HOTCHKISS
DELIA
Shweitzer Res
Crawford Res
Black Canyon National Monument
Gould Res
OLATHE
Crystal Res
MONTROSE
Fairview Res
Montrose Res
Olathe Res
Morrow Pt Res
Blue Mesa Res
Curecanti Nat. Rec. Area
GUNNISON
PARLIN
Hot Springs Res
PITKIN
SARGENTS
GOTHIC
Meridian Lk
CRESTED BUTTE
Spring Ck Res
Taylor Park Res
Vouga Res
Needle Ck Res
Soderquist Res
Upper Dome Res
Mc Donough Res 2
Mc Donough Res
Frank Walters Res
Silver Jack Res
Ridgway Res
RIDGWAY
Ouray Res
OURAY
LAKE CITY
Lake San Cristobal
COLONA
NOTES
1 SELECTED MODEL NODES ARE SHOWN FOR THE SOLE PURPOSE OF ASSISTING READERS WHO ARE UNFAMILIAR WITH THE STUDY AREA TO ORIENT THEMSELVES WHEN STUDYING THE MODEL NETWORK DIAGRAM PRESENTED IN FIGURE 2.1
2 SOME NODES DO NOT HAVE PRECISE PHYSICAL LOCATIONS. NODES ARE USED IN THE MODEL TO CONNECT LINKS WHICH REPRESENT STREAM REACHES. ONE NODE MAY HAVE SEVERAL PHYSICALLY SEPARATED INFLOWS COMING INTO IT IF THE MODEL DOES NOT ADDRESS FLOWS IN THE INTERMEDIATE REACHES. FOR EXAMPLE, NODE 30 IS NOT SHOWN BECAUSE IT REPRESENTS ALL INFLOW TO BLUE MESA RESERVOIR INCLUDING THE LAKE FORK, CEBOLLA CREEK, GUNNISON RIVER, SOAP CREEK AND OTHER TRIBUTARIES
N
5 0 5
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
SELECTED BASIN MODEL NODES
HDR ENGINEERING, INC
CU Center For Economic Analysis · WBLA Inc
US Bureau of Reclamation Woodward Clyde Consultants
DATE April 1980
FIGURE 7.2

8.0 DEMAND FORECASTS

8.1 INTRODUCTION

This chapter presents forecasts of future water and recreation demands in the study area and forecasts of the future demand for baseload and peaking power which could be produced in the study area. Such forecasts are affected by a number of economic, social and institutional factors which could change significantly in the future from what is predicted at the time a forecast is prepared. Therefore, a single forecast was not considered appropriate and three economic scenarios were used to develop these forecasts to bracket what may actually occur in the future. A 50-year planning horizon, 1985-2035, was used in preparing the forecasts.

8.2 POPULATION FORECASTS

The State of Colorado is divided into 14 Planning and Management Regions for the purpose of carrying out economic and other planning activities. Detailed economic and demographic data is maintained for each of the 14 regions by the state. As shown in Figure 8.1, nearly all of the study area lies in Region 10. Therefore, forecasts were prepared initially for Planning Region 10 and then disaggregated by county. The county forecasts were then used to prepare forecasts of the study area.

The methodology used to produce the forecasts presented in this chapter involved both econometric modeling and the "TFS" Regional Forecasting Methodology as described below. Econometric modeling involves statistically identifying the key factors that account for the historical growth in the economy and population of a region. Given the importance of any region's economic base to its overall performance, the econometric analysis focused on Region 10's key economic sectors of agriculture, energy, food and wood products, government, and tourism and recreation. The rest of the region's economy was analyzed in terms of the performance of these key economic base

sectors. For population, the United States trends in net natural increase and the linkage between economic performance and net migration were utilized.

Trends in the key underlying factors that were identified as important in the econometric modeling analysis were obtained from the United States Bureau of the Census and from Wharton Econometric Forecasting Associates. Wharton is a commercial firm that has provided forecasts of the United States and world economies on a regular basis for a number of years. Examples of trends obtained from Wharton include projections of gross national product, interest rates, United States exports of food and feed, and oil prices.

The TFS methodology is a regional economic and population forecasting and simulation tool that has been under development and in use for more than ten years. It is named after its developers: G. Treyz, A. Friedlander, and B. Stevens (G. Treyz, et.al., 1985). It is used in a number of states to develop long-range forecasts and to analyze the impacts of alternative events and assumptions on regional economies and populations. The methodology incorporates econometrically estimated dynamic relations, a detailed input-output model, and a fully integrated set of regional economic accounts. The TFS methodology was used to allow the study to incorporate a variety of alternative assumptions about the future in the forecasting process.

8.2.1 Definition of Forecast Scenarios

Three forecast scenarios were utilized in preparing population projections. These scenarios were termed Baseline, Moderate and High and can be generally described as follows:

Baseline - assumes that economic growth in the study area will be influenced, as in the past, by national and world economic conditions involving oil prices, exports of food and feed, and other factors. The assumed course of the United States and world economies is based on Wharton's recent baseline forecast (Wharton, 1987). With respect to population growth, net migration is assumed to follow area economic

trends, as in the past; and net natural increase is assumed to follow the U.S. Census Bureau's Middle Series projection.

Moderate - assumes that economic growth in the study area will be influenced, as in the past, by national and world economic conditions related to oil prices, exports of food and feed, and other factors. The assumed course of the United States and world economies is based on Wharton's recent baseline forecast (Wharton, 1987) with the exception that real oil prices are assumed to escalate at a more rapid rate than in Wharton's forecast. With respect to population growth, net migration is assumed to follow area economic trends, as in the past; and net natural increase is assumed to follow the average of the U.S. Census Bureau's Middle and High Series projections.

High - assumes that economic growth in the study area will be influenced, as in the past, by national and world economic conditions involving oil prices, exports, and other factors. The assumed course of the United States and world economies is based on Wharton's recent baseline forecast (Wharton, 1987), with the exception that real oil prices are assumed to escalate at an even more rapid rate than in the Moderate Scenario. Moreover, several large mining projects are assumed to be developed. With respect to population growth, net migration is assumed to follow area economic trends, as in the past, and net natural increase is assumed to follow the U.S. Census Bureau's High Series projection.

8.2.2 Region 10 Forecasts

The population forecasts for Region 10 and its respective compound annual growth rate (CAGR) are presented in Table 8.1. The forecasts are also shown graphically on Figure 8.2.

TABLE 8.1

Population Forecasts By Scenario for Region 10: 1985-2035
(Thousands of Persons)

	YEAR						
	1985	1995	2005	2015	2025	2035	CAGR %
Baseline	66.2	72.9	80.4	87.8	93.2	97.4	0.8
Moderate	66.2	78.3	91.4	103.1	113.3	122.5	1.2
High	66.2	83.1	102.2	119.3	136.2	153.7	1.7

CAGR denotes Compound Annual Growth Rate.

8.2.3 Distribution of Forecasts to Water Providers

Forecasts of Region 10 were first distributed to the six counties in the region based on the State Demographer's county level forecasts of population. For example, the State Demographer forecasted that Gunnison County's population growth accounted for 24 percent of the six-county, Region 10 forecast for the period 1986-2001. Therefore, for the Baseline scenario, the Gunnison forecast is 24 percent, (23,400) of the total forecasted population through 2035. The county distribution for the Moderate and High scenarios were adjusted to account for county-specific factors.

8.2.4 Distribution of Forecasts to Study Area

The study area includes all or parts of six counties. These counties and the percentage of their land area which lies within the study area are as follows:

Gunnison -	80%	Ouray -	100%
Saguache -	20%	Montrose -	30%
Hinsdale -	45%	Delta -	10%

Saguache County is partially within the study area but is not included in Region 10. Therefore, it was necessary to estimate the population of Saguache County that lies within the study area and also to differentiate the population of the other five counties into in-basin population and out-of-basin population. This was accomplished by using the State Demographer's data which breaks down county population by incorporated areas and unincorporated areas. U.S. Census Bureau data which presents population by discrete districts was also used. That data, in conjunction with a map study to determine the area in- and out-of-basin formed the basis of disaggregating county population to the study area.

Municipal and Industrial (M&I) water demand forecasts are discussed in this chapter. The M&I forecasts were prepared on the basis of water providers within the study area identified as follows:

Project 7
City of Gunnison
Town of Crested Butte
Mt. Crested Butte
Lake City
Ouray
Other

It was necessary, therefore, to finally present the study area population disaggregated by water providers. This was done on the basis of Region 10 and U.S. Census Bureau data for incorporated, unincorporated and enumeration districts (small districts sized such that one enumerator can supervise census data collection). Population forecasts by water provider are presented in Table 8.2.

TABLE 8.2

Study Area Population Disaggregation - Water Provider Format

ENTITY	1986 IN-Basin POPULATION		2035 BASELINE IN-Basin POPULATION		2035 MODERATE IN-Basin POPULATION		2035 HIGH IN-Basin POPULATION	
Gunnison		6,384		12,600		18,000		23,700
Crested Butte		1,016		2,000		2,800		3,800
Mt Crested Butte		348		700		1,000		1,300
Lake City		206		400		500		700
Ouray		641		700		800		1,000
Project 7:								
Montrose	9,957		12,200		16,700		21,800	
Olathe	1,280		1,600		2,100		2,800	
Delta	3,915		6,000		6,300		7,100	
In-Basin Montrose County (75%)	9,000		11,100		15,075		19,650	
In-Basin Delta County	3,000		4,600		4,800		5,500	
In-Basin Ouray County (33%)	405		429		528		660	
Total Project 7	27,557	27,557	35,929	35,900	45,503	45,500	57,510	57,500
Other:								
In-Basin Gunnison County	3,932		7,700		11,100		14,600	
In-Basin Saguache County	250		300		300		400	
In-Basin Hinsdale County	100		200		300		300	
In-Basin Montrose County (25%)	3,000		3,700		5,025		6,550	
In-Basin Ouray County (67%)	821		871		1,072		1,340	
Total Other	8,103	8,103	12,771	12,800	17,797	17,800	23,190	23,200
TOTAL STUDY AREA		44,255		65,100		86,400		111,200

Notes:

1. Percentages of Montrose, Delta, and Ouray in-basin populations served by Project 7 are estimated from 1980 Census Bureau data for enumeration districts covered by Project 7.

2. Population figures are rounded to nearest 100 for future projection scenarios.

8.3 Municipal and Industrial Water Demand

Municipal and Industrial (M&I) water demand is small relative to total water demand in the study area. The methodology selected for preparing the M&I water demand projections was based on an approach which is consistent with the preliminary level of this study and the relative magnitude of this segment of total water demand. The methodology adopted for this study consists of applying historical average daily consumptive use figures, which include light industrial usage, to population to arrive at M&I water demand. Other industrial demand is determined by forecasting certain major mining development projects and adding their water demand to the M&I demand. This approach makes no attempt to investigate the effect of cost on water demand nor does it consider the climatological factors which affect water demand. These refinements are not considered to be warranted for this level of study. Also, conservation measures which might reduce future per capita water use below historical levels have not been considered because such measures are considered separately when evaluating potential conservation components.

8.3.1 Historical M&I Water Use

M&I water use in the study area is defined to include all residential, commercial and industrial customers served by public and private domestic water delivery systems. The largest supplier of M&I water in the study area is Project 7 which serves 62 percent of the population and supplies 56 percent of the total M&I water used in the study area. Five other water suppliers; the City of Gunnison, the Town of Crested Butte, the Town of Mt. Crested Butte, the City of Ouray, and Lake City comprise the other major M&I water suppliers in the study area. These six entities combined provide about 83 percent of all M&I water used within the study area. The remainder of the M&I water demand in the study area is provided by town supply systems or by private wells and springs. For the purpose of this study, forecasts of future M&I water demand are based on the six major water suppliers and a seventh category termed "other" which combines all of the other small systems, wells and springs not included in the major suppliers.

Historical data regarding populations served, total diversions, and resulting per capita water usages are available on a monthly basis for Project 7 Water Authority and the Town of Mt. Crested Butte. Similar records for the City of Gunnison are available only through 1980. Data for the other entities within the study area are limited and less precise due to less rigorous flow measurement and record keeping systems.

Table 8.3 presents historical water diversion requirements for the six major water suppliers in the study area. This table presents annual water usage expressed in gallons per capita per day (gpcd) for each of the entities. The figures in Table 8.3 represent a composite of all user types whether they be residential, commercial, industrial, or institutional.

TABLE 8.3

Historical Water Demands

	City of Gunnison	Crested Butte	Mt Crested Butte *	Lake City	Ouray	Project 7	Other
1980							
Demand (AF)	1,627	ND	96	ND	ND	#	ND
Population	5,785		272				
Avg GPCD	251		314				
1981	<1971>		(1)				
Demand (AF)	1,372	ND	62	ND	ND	6,114	ND
Population	5,293		290			26,564	
Avg GPCD	231		191			205	
1982	<1972>		(3)				
Demand (AF)	1,517	ND	161	ND	ND	5,822	ND
Population	5,439		311			27,269	
Avg GPCD	249		463			191	
1983	<1973>						
Demand (AF)	1,224	ND	283	ND	ND	5,540	ND
Population	5,585		310			27,813	
Avg GPCD	196		814			178	
1984	<1974>						
Demand (AF)	1,245	ND	354	ND	ND	5,741	ND
Population	5,612		318			27,680	
Avg GPCD	198		995			185	
1985	<1975>		(2)				
Demand (AF)	1,056	ND	324	ND	ND	5,971	ND
Population	5,639		329			27,319	
Avg GPCD	167		878			195	
1986	<1976>						(Est'd)
Demand (AF)	1,125	307	339	110	872	5,691	1,815
Population	5,516	1,016	348	206	641	27,557	8,103
Avg GPCD	182	270	871	477	1,214	184	200
Average	211	270	646	477	1,214	190	200

\# Project 7 began operating in June, 1980

ND No Data or insufficient data

<1971> No recent data are available from the City of Gunnison. Data for the bracketed year are supplied instead.

* Data supplied by Crested Butte Water and Sanitation District. Water requirements include employees, skiers and snowmaking water associated with Crested Butte Mountian Resort (CBMR) through 1984. Since 1985, CBMR has provided its own snowmaking water, which amounts are not included herein. Potable water continues to be provided to CBMR by the District.

(2) Indicates number of months for which no data are available. Values for those months were simulated by averaging values supplied by the District for the year prior and the year following.

From the data presented in Table 8.3, it can be observed that in areas where population is somewhat stable throughout the year, such as Montrose, Delta, and Gunnison, water usage has been around 200 gpcd with relative consistency. Recreation and tourism based communities, however, have exhibited much greater demand rates, ranging from 270 to 1200 gpcd. This is to be expected when considering that all water used by tourists, skiers, and seasonal employees is allocated to a relatively small base of permanent residents. This is especially true in Mt. Crested Butte, Lake City, and Ouray.

It is noted that the water demands for Mt. Crested Butte in 1982, 1983 and 1984 include an unknown quantity of snowmaking water supplied to the Crested Butte Mountain Resort (CBMR) by the Crested Butte Water and Sanitation District (District). The District is the purveyor of all potable water to the Town of Mt. Crested Butte, including the ski area, which is owned and operated by CBMR. Since 1985, CBMR has provided its own water for snowmaking purposes, independent of the District. Snowmaking water is not included in the M&I water demand forecasts, but is discussed separately in a later section of this chapter. Therefore, for Mt. Crested Butte, the unit demand rate used to forecast M&I water demand is based on 1985 and 1986 data supplied by the District, which does not include snowmaking. For confirmation purposes, records provided by the District through October of 1987 support the validity of this assumption.

8.3.2 M&I Water Demand Forecasts

At present, there is no major industrial base (from the standpoint of water demand) in the study area. In the future, the only major industrial development requiring large volumes of water is expected to be in the area of mining. The water demand forecast for M&I, therefore, has been divided into two areas as follows: M&I (comprised of residential, commercial and light industrial water uses); and mining. This was done for the following reasons:

- The historical M&I water usage is directly tied to population and economic trends. Furthermore, existing data combines the two.

- There are significant undeveloped mineral resources existing in the study area which, if developed, could result in a relatively significant water demand.

- Proposed mining operations are independent of M&I supplies and presently have significant conditional water rights decrees.

Forecasts of M&I water demands presented in this chapter are based on the three population scenarios described previously. In all cases, and most importantly for the Crested Butte area, the population figures represent permanent residents and are consistent with the U.S. Census Bureau and State Demographer's population distribution records and estimates. Additional water usage by non-permanent residents, as well as commercial and industrial customers are reflected in the per capita use rates.

Municipal water use is usually expressed as "per capita consumption" which is actually the amount of water that must be delivered to a household in order to meet its needs. The large majority of the water delivered to a household is not lost to other uses. The "per capita consumption" is termed "diversion requirement" in this report to differentiate it from consumptive use which is water that is consumed and lost to other uses. The figures presented in Table 8.3 are diversion requirements and not consumptive use. Per capita M&I diversion rates selected for use in preparing forecasts of future demand are presented in Table 8.4.

Historical consumptive use patterns can sometimes be predicted using wastewater return flows. However, due to the age and variety of wastewater return flow systems in the basin, the presence of varying degrees of groundwater inflow significantly distorts meaningful wastewater flow data. Therefore, wastewater flow rates are not considered to provide a good measure of M&I return flow for this study. It is considered appropriate, however, in

the absence of valid local data, to adopt a consumptive use of 30 percent of the amount diverted for M&I use in primarily residential/commercial areas without intensive industrial activity (Metcalf and Eddy, 1979). This is particularly applicable in this study area where heavy industrial water usage is primarily mining activity which would have independent water supply facilities. The consumptive use unit rates proposed for establishing future M&I demands, exclusive of mining operations, are also presented in Table 8.4.

TABLE 8.4

Per Capita Use Rates
(gallons per capita per day, gpcd)

Entity	Average Historical Diversion Rate	Proposed Diversion Rate	Proposed Consumptive Use
Gunnison	211	200	60
Crested Butte	270	300	90
Mt. Crested Butte (1985-86)	875	900	270
Lake City	477	500	150
Ouray	1214	1200	360
Project 7	191	200	60
Other	NA	200	60

Forecasts of future M&I diversions and consumptive use are presented in Table 8.5. Per capita usage was assumed constant throughout the planning horizon in each of the scenarios presented. Although it is conceivable that unit demand factors may decrease during the forecast horizon due to more efficient water management practices and technology, the magnitude of potential change is not considered significant in light of total basin water demand. Therefore, constant demand factors were assumed in projecting baseline, moderate, and high scenario demands.

TABLE 8.5

M&I Water Demand Forecasts

ENTITY	1986 ACTUAL POPULATION	1986 ACTUAL DIVERSION (AF)	1986 ACTUAL CONSUMPTIVE USE (AF)	DEMAND FACTORS DIVERSION (GPCD)	DEMAND FACTORS CONSUMPTIVE USE (GPCD)	2035 BASELINE POPULATION	2035 BASELINE DIVERSION (AF)	2035 BASELINE CONSUMPTIVE USE (AF)	2035 MODERATE POPULATION	2035 MODERATE DIVERSION (AF)	2035 MODERATE CONSUMPTIVE USE (AF)	2035 HIGH POPULATION	2035 HIGH DIVERSION (AF)	2035 HIGH CONSUMPTIVE USE (AF)
1) City of Gunnison	6,384	1,309	393	200	60	12,600	2,823	847	18,000	4,033	1,210	23,700	5,310	1,593
Town of Crested Butte	1,016	307	92	300	90	2,000	672	202	2,800	941	282	3,800	1,277	383
2) Mt Crested Butte (CBW&SD)	348	339	102	900	270	700	706	212	1,000	1,008	302	1,300	1,311	393
Lake City	206	110	33	500	150	400	224	67	500	280	84	700	392	118
City of Ouray	641	872	262	1,200	360	700	941	282	800	1,075	323	1,000	1,344	403
Project 7	27,557	5,691	1,707	200	60	35,900	8,043	2,413	45,500	10,194	3,058	57,500	12,883	3,865
Other	8,103	1,815	545	200	60	12,800	2,868	860	17,800	3,988	1,196	23,200	5,198	1,559
TOTAL STUDY AREA	44,255	10,443	3,134			65,100	16,277	4,883	86,400	21,519	6,456	111,200	27,714	8,314

Note:

1. Based on average historical use (See Table 8.3) in City of Gunnison.

2. Mt Crested Butte water requirements do not include snowmaking.

8.3.3 Mining Water Demand Forecasts

Outside of the light industrial water users which are assumed to be served by the municipal water systems, the only other future industrial water demand of significant proportion is anticipated to come from the mining industry. Although mining activity in the study area is presently at a standstill, potential significant mining operations do exist, and have been factored into the planning process as follows:

- o Coal. Virtually all significant coal reserves in the Gunnison Basin are in the North Fork Valley, which is outside the study area with respect to project demands. Lower Gunnison conditional water rights associated with potential coal mining development were addressed in the previous chapter dealing with hydrologic model configuration.

- o Molybdenum. Historically, Colorado has produced more than half of the world's supply of molybdenum. If there is a return of favorable worldwide molybdenum market conditions, the Mount Emmons molybdenum deposit near Crested Butte is considered to be of major importance. The Mount Emmons Mine proposed by AMAX would process 20,000 tons of ore per day for 27 years, following a seven-year construction period. The water requirement for the mining and milling process is estimated at 3000 af per year consumptive use. This demand is included only in the high scenario forecast beginning in year 2000 and continuing through the end of the forecast horizon on the assumption that some future development of the Mount Emmons deposit may occur.

- o Base and Precious Metals. Complex ores containing gold, silver, zinc, and lead have historically been mined within the study area in the Tincup, Tomichi, Lake City, Red Mountain, and Uncompahgre Districts. The most important of these with respect to future production are the deposits in the San Juan Region, where the largest producers have been the Camp Bird Mine and the Idarado Mine,

both near Ouray. Whereas the Idarado Mine has been closed since 1978, the Camp Bird Mine has remained in a standby mode, and is presently staffing up to resume production. The mine is capable of a production rate of 200-300 tons per day, which would consume approximately 40 af of water per year. This demand figure is included in the baseline scenario and is increased in the moderate and high scenarios.

- Other. The proposed Red Mountain Alunite Mine near Lake City is reported to have a consumptive use requirement of approximately 30 af per year. This demand is used to represent "other" mining for the baseline scenario, beginning in the year 2000 and continuing throughout the forecast horizon. For the moderate scenario, a demand of 80 af per year is projected across the same time frame, and 120 af annually for the high scenario. An additional undefined mining demand of 3000 af is forecast into the high scenario, in the event that the alunite mill is located within the study area or that a major resource discovery which is presently unidentified is developed.

A summary of the forecasted consumptive use demand for mining is presented in Table 8.6. For comparison purposes, the estimated consumptive water use in the study area in 1986 related to mining is estimated to be approximately 30 af annually.

TABLE 8.6

Mining Water Demand (af)

	2035 Baseline		2035 Moderate		2035 High	
Sector	Diversion	Consumptive Use	Diversion	Consumptive Use	Diversion	Consumptive Use
Molybdenum	0	0	0	0	24,000	3,000
Base and Precious Metals	320	40	640	80	960	120
Other	240	30	640	80	24,000	3,000
Total	560	70	1,280	160	48,960	6,120

8.4 AGRICULTURAL DEMANDS

This section quantifies the present diversion and consumptive use of water and estimates future agricultural water demands within the study area.

Agricultural water demand within the study area is composed of two components; irrigated agriculture and livestock production. Irrigated agriculture is the largest user of water in the study area. For the purposes of this study, irrigated agriculture has been separated into the following three areas: Uncompahgre Valley, Bostwick Park and the Upper Gunnison area.

The Uncompahgre Valley is the largest of the three areas and utilizes both the Gunnison and Uncompahgre Rivers as sources of irrigation water. Irrigated agriculture in the Upper Gunnison area is primarily concentrated in the valleys along the major streams. Irrigation in this area does not presently utilize stored water but is dependent on the use of direct flow diversions from the Gunnison River and its tributaries. The Bostwick Park area is located about eight miles east of Montrose and is the smallest of the three areas. The source of irrigation water for this area is the Silver Jack Reservoir on the Cimarron River. Full descriptions of these systems are presented in Appendix B.

8.4.1 Methodology

Irrigation water demands are a function of total irrigated acreage, crop type, consumptive use, and irrigation efficiencies. To estimate water demands, the amount of land that is presently irrigated and the area that could potentially be irrigated were determined, the cropping pattern was defined, an average crop consumptive use figure was calculated for each crop type, and irrigation efficiencies were estimated. Water demand due to livestock production has been similarly estimated using established consumption rates and current and projected livestock population estimates.

8.4.2 Historical Agricultural Trends

Agricultural production within the study area, while declining in its relative contribution to total earnings, is a significant component of the overall economy in the study area. Agriculture accounted for 4.4 percent of total earnings within Planning Region 10 in 1984, down from 6.1 percent in 1980 and 12.8 percent in 1970. In terms of inflation-adjusted dollars from 1967 to 1985, the value of crop and livestock production in Planning Region 10 has shown an average annual growth rate of 0.4 percent.

8.4.3 Irrigated Acreage

Detailed land classification studies have been carried out by the U.S. Bureau of Reclamation (USBR) in the past (USBR, 1965, 1973, 1976). In addition, other data related to irrigated acreage is also available from the USBR (USBR, 1981, 1982), the Soil Conservation Service, the State Engineer's Office, the U.S. Geological Survey, and County Land Assessors. The available data was reviewed in order to determine the amount of land that is presently in use for irrigated agriculture and the amount of land that could possibly be brought into production in the future.

Estimates of presently irrigated acreages and arable lands within the study area are presented in Table 8.7. These estimates are primarily based on detailed land classification surveys which involved separating arable lands from non-arable lands and delineating currently irrigated acreages. The surveys used physical factors of soil, topography, and drainage in conjunction with economic factors of productivity, production costs, and land development to identify lands suitable for irrigated agriculture. In areas where land classification surveys were not available, irrigated acreage estimates were obtained from the Soil Conservation Service, U.S. Geological Survey, Colorado State Engineer's Office, and County Assessors.

Lands included in Classes 1 through 3 are suitable for irrigated agriculture based on physical parameters; however, production in all cases may

not be economically justified with current technology and market conditions. Lands in Class 6 are normally considered to be unsuitable for irrigated agriculture because of physical limitations, but the Class 6 acreage shown in Table 8.7 is currently being irrigated.

Much of the basic data used to derive the figures in Table 8.7 was generated in the late 1960's and 1970's. The figures for irrigated acreage in the Uncompahgre Valley and Bostwick Park are considered to be accurate because they check with figures maintained by the Uncompahgre Valley Water Users Association and the Bostwick Park Water Conservancy District. In the case of the Upper Gunnison area, the USBR figures generated in the 1960's were checked against the 1978 SCS ditch survey figures and the two sets of figures agreed closely. In order to investigate changes that may have taken place since 1978, figures were obtained for Gunnison County from the Assessor's Office (Abstract of Assessment and Levies for Gunnison County). That data is presented in Table 8.8

TABLE 8.7

Summary of Irrigated Lands

BASIN / PROJECT	LANDS			
	Presently Irrigated			Non-Irrigated
	Class 1-3 (ac)	Class 6 (ac)	Total (ac)	Class 1-3 (ac)
Upper Gunnison				
East / Slate	5,910 1/	1,410 1/	7,320	1,410 1/
Gunnison River (Above Blue Mesa)	4,670 1/	1,860 1/	6,530	600 1/
Ohio Creek	9,670 1/	1,040 1/	10,710	3,700 1/
Tomichi Creek	15,440 1/	1,150 1/	16,590	9,220 1/
Cochetopa Creek	4,460 1/	1,260 1/	5,720	4,480 1/
Quartz Creek	N.A.	N.A.	2,520 2/	N.A.
Lake Fork Creek	N.A.	N.A.	1,600 2/	N.A.
Cebolla Creek	N.A.	N.A.	4,600 2/	N.A.
Soap Creek	N.A.	N.A.	400 2/	N.A.
Taylor River	N.A.	N.A.	360 2/	N.A.
Big Blue	N.A.	N.A.	1,000 2/	N.A.
Crystal Creek	N.A.	N.A.	630 2/	N.A.
Subtotal	40,150	6,720	57,980	19,410
Bostwick Park Project				
Bostwick Park Area	2,727 3/	195 3/	2,922	1,278 3/
Cedar Creek Area	196 3/	22 3/	218	13 3/
Shinn Park & Kinikin Heights Area	1,261 3/	412 3/	1,673	260 3/
Cimarron Area	316 3/	1,825 3/	2,141	104 3/
Subtotal	4,500	2,454	6,954	1,655
Uncompahgre				
South Canal	4,400 4/	2,620 4/	7,020	160 5/
West Canal	4,730 4/	1,020 4/	5,750	130 5/
M&D Canal	22,650 4/	2,600 4/	25,250	580 5/
Loutzenhizer Canal	3,690 4/	2,510 4/	6,200	140 5/
Selig Canal	6,490 4/	3,470 4/	9,960	230 5/
Ironstone Canal	20,230 4/	2,320 4/	22,550	510 5/
East Canal	4,320 4/	3,350 4/	7,670	170 5/
Garnet Canal	1,500 4/	90 4/	1,590	40 5/
Non-project lands within project boundaries	8,000 5/	0 5/	8,000	0 5/
Log Hill Mesa	620 6/	0 6/	620	7,210 6/
Dallas Creek / Colona	7,070 6/	380 6/	7,450	0 6/
Cow Creek	N.A.	N.A.	3,300 2/	N.A.
Subtotal	83,700	18,360	105,360	9,170
TOTAL	128,350	27,534	170,294	30,235

1/ From Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Table 25, page 40.
2/ No land classification data available, acreages from SCS, USGS, and State Engineer estimates.
3/ From Bostwick Park Definite Plan Report, Supplemental Water Supply Appendix, September 1965, Table 8, page 33.
4/ From Dallas Creek Definite Plan Report, Water Supply Appendix, November 1976, Table 31, page 64.
5/ From Dallas Creek Definite Plan Report, Project Lands Appendix, November 1976, page 7.
6/ From Dallas Creek Definite Plan Report, Water Supply Appendix, November 1976, Table VII, page 106.

The data in Table 8.8 indicates that irrigated acreage in Gunnison County increased 1.3 percent from 1978 to 1982. The 1987 figure, however, shows a 5.4 percent decline from 1978. Some agricultural land has been subdivided and rezoned from agriculture to residential. Some of that land has been developed, however, much of it has not and is still used as irrigated pasture land. Based on an analysis of the Gunnison County data, the figures presented in Table 8.7 for irrigated acreage in the Upper Gunnison area have a margin of error of less than 10 percent. Since Gunnison County contains about 80 percent of all irrigated agricultural land within the Upper Gunnison area, the figures presented in Table 8.7 were considered suitable for use in developing agricultural water demands in the study area.

TABLE 8.8

Irrigated Agricultural Lands in Gunnison County

Year	Irrigated Acreage
1987	41,496
1986	42,187
1985	43,240
1984	43,791
1983	43,718
1982	44,498
1981	44,846
1980	44,521
1979	43,371
1978	43,867

Source: Abstract of Assessments and Levies for Gunnison County, Gunnison County Assessor's Office

8.4.4 Cropping Pattern

To determine consumptive use rates, an average crop distribution was established to develop weighted crop coefficients for use in the Blaney-Criddle Equation. The crop distribution used in this study effort is primarily based upon information developed for the USBR's Upper Gunnison, Uncompahgre, Bostwick Park, and Dallas Creek Projects studies. This data was developed during the 1965 to 1976 time frame does not correspond to current cropping patterns in all cases due to changes in the regional and national agricultural markets. Two notable exceptions are the decline of sugar beets and malting barley production in the Uncompahgre Valley, whose acreage has largely been replaced with increased corn and alfalfa production as well as small amounts of vegetable crops. The cropping patterns presented in Table 8.9 and their associated coefficients are based on present conditions and were used in this study. This cropping pattern is assumed to remain constant throughout the study period.

8.4.5 Crop Consumptive Use Requirements

To estimate net monthly crop consumptive use, historical climate data for the 32-year hydrologic study period (1952-1983) was utilized. Actual consumptive use figures were calculated for that period on a monthly and annual basis. The monthly values were summed to obtain equivalent annual values. These annual values were then averaged to obtain a single average annual consumptive use figure for each irrigated area.

Crop consumptive use requirements were calculated using the Blaney-Criddle Method. Net consumptive use rates were determined by the Soil Conservation Service Method (SCS, 1970). In the Soil Conservation Service Method, effective precipitation is subtracted from the Blaney-Criddle gross crop requirement to arrive at the net consumptive use rates.

Monthly average temperature and precipitation data from 1952 through 1983 for Cochetopa, Delta, Gunnison, Montrose, and Ouray weather stations served as

input to the Blaney-Criddle Method. These data were weighted by various factors (see Table 8.10) to simulate climatic conditions for the individual subbasins.

Growing season parameters used to determine the temperal distribution of crop consumptive use are summarized in Table 8.11. These parameters were applied to daily temperature data to determine beginning and ending consumptive use periods for each subbasin for each year during the 32-year study period.

TABLE 8.9
Cropping Patterns

Area	Crop Type	Percent of Irrigated Area
Ohio Creek	Pasture Grass	100
Lake Fork Creek	Pasture Grass	100
Cebolla Creek	Pasture Grass	100
Soap Creek	Pasture Grass	100
Big Blue Creek	Pasture Grass	100
Gunnison River (above Blue Mesa)	Pasture Grass	100
East/Slate River	Pasture Grass	100
Tomichi Creek	Pasture Grass	100
Cochetopa Creek	Pasture Grass	100
Taylor River	Pasture Grass	100
Bostwick Park	Alfalfa	40
	Pasture Grass	27
	Small Grain	25
	Potatoes	5
	Dry Beans	3
Loghill Mesa	Pasture Grass	95
	Small Grain	5
Dallas Creek	Pasture Grass	95
	Small Grain	5
Cow Creek	Pasture Grass	95
	Small Grain	5
Uncompahgre Project	Alfalfa	24
	Pasture Grass	24
	Small Grain	22
	Corn	20
	Dry Beans	7
	Onions	2
	Fruit	1

TABLE 8.10

Climatic Conditions for Individual Sub-Basins

Area	Weather Station(s)	Weight (%)
Ohio Creek	Gunnison	100
Lake Fork Creek	Gunnison	100
Cebolla Creek	Gunnison	100
Soap Creek	Gunnison	100
Big Blue Creek	Gunnison	100
Gunnison River (above Blue Mesa)	Gunnison	100
East/Slate River	Cochetopa	100
Tomichi Creek	Cochetopa	100
Cochetopa Creek	Cochetopa	100
Taylor River	Cochetopa	100
Bostwick Park	Montrose	50
	Ouray	50
Loghill Mesa	Montrose	25
	Ouray	75
Dallas Creek	Montrose	25
	Ouray	75
Cow Creek	Montrose	25
	Ouray	75
Uncompahgre Project	Delta	50
	Montrose	50

TABLE 8.11
Growing Season Parameters

Crop Type	Earliest Crop Use of Moisture	Latest Crop Use of Moisture	Growing Season (days)
Alfalfa	50 F Mean	28 F Frost	NA
Pasture Grass	45 F Mean	45 F Mean	NA
Small Grain	45 F Mean	32 F Frost	130
Potatoes	60 F Mean	32 F Frost	130
Dry Beans	60 F Mean	32 F Frost	100
Corn	55 F Mean	32 F Frost	140
Onions	45 F Mean	32 F Frost	140
Fruit	50 F Mean	45 F Mean	NA

Growing season for items marked NA were determined from temperature records for each year of the study period and vary each year.

8.4.6 Diversion Requirements

The amount of water diverted for agricultural use is calculated by adding off-farm and on-farm losses to the amount of water consumptively used by the crop. Off-farm losses occur between the stream diversion point and the farmers' headgates. This included evaporation and seepage from the ditch as well as administrative losses. The administrative losses account for the additional water that must be diverted in order to provide sufficient head to deliver the required amount of water to the headgate. On-farm losses result primarily from deep percolation and vary throughout the study area due to changes in soil type and ground water conditions. On-farm and off-farm efficiencies are equal to one minus the on-farm and off-farm losses,

respectively. The combined or overall efficiency of the system is the product of the on-farm and off-farm efficiencies. The values used in the study are presented in Table 8.12.

TABLE 8.12

Irrigation Efficiencies

Irrigated Area	On-Farm Efficiency (Per Cent)	Off-Farm Efficiency		Overall 1/ Efficiency (Per Cent)
		Conveyance Efficiency (Per Cent)	Administrative Efficiency (Per Cent)	
Upper Gunnison 2/ (All Subbasins)	30	85	95	24
Bostwick Park				
Cimarron Area 3/	47	90	95	40
Bostwick Park Area 3/	51	60	95	28
Shinn Park and Kinikin Heights Area 3/	51	65	95	31
Cedar Creek Area 3/	47	95	95	42
Uncompahgre				
South Canal 4/				35
West Canal 4/				35
M&D Canal 4/				35
Loutzenhizer Canal 4/				35
Selig Canal 4/				35
Ironstone Canal 4/				35
East Canal 4/				35
Garnet Canal 4/				35
Non-project lands within project boundaries 4/				35
				35
Log Hill Mesa 5/	50	85	95	40
Dallas Creek / Colona 5/	50	85	95	40
Cow Creek 5/	50	85	95	40

1/ Overall Eff. = (Conveyance Eff. + Administrative Eff. - 1) X On-Farm Eff.
2/ From Upper Gunnison Concluding Report, Appendix B, August 1973, p. 46.
3/ From Bostwick Park Definite Plan Report, Supplemental Water Supply Appendix, September 1965, pp. 35-38.
4/ From Uncompahgre Project History, Volume 76, 1984, p. 100.
5/ From Dallas Creek Definite Plan Report, Appendix B, November 1976, p. 63.

8.4.7 Baseline, Moderate, and High Growth Conditions

The baseline condition for irrigated agricultural diversions and consumptive use assumes continued operation of currently irrigated lands with associated historical cropping patterns and water shortages. The moderate growth scenario assumes providing a full irrigation water supply to all currently irrigated lands. The high growth scenario assumes providing a full water supply to all currently irrigated lands as well as to all identified Class 1 through 3 arable lands that are presently not irrigated. This scenario reflects the potential maximum growth in agricultural production and its associated water demand.

8.4.8 Irrigated Agricultural Demand Forecasts

Table 8.13 summarizes forecasted agricultural water demands within the study area. Agricultural consumptive use varies from 229,000 af under the baseline scenario to 283,000 af under the high growth scenario, a difference of 24 percent.

8.4.9 Livestock Water Demands

The majority of livestock production in the study area is in the form of cattle and sheep grazing operations with minor hog production. Additionally, a few small-scale dairy and feedlot operations are present in Delta and Montrose Counties but are insignificant in terms of basinwide consumptive use of water.

Daily water requirements and consumptive use rates for beef cattle, sheep and hogs are presented in Table 8.14 The rates were then applied to livestock population projections to determine basinwide water demand due to livestock production.

TABLE 8.13

Summary of Irrigation Demand Computation

BASIN / PROJECT	UNIT RATES			DIVERSIONS			CONSUMPTIVE USE		
	Unit Diversion Requirement (af/ac)	Unit Consumptive Use (af/ac)	Average Shortage (%)	Baseline Condition (af/yr)	Moderate Growth Condition (af/yr)	High Growth Condition (af/yr)	Baseline Condition (af/yr)	Moderate Growth Condition (af/yr)	High Growth Condition (af/yr)
Upper Gunnison									
East / Slate	3.92 1/	0.94 5/	25.1 6/	21,492	28,694	34,222	5,154	6,881	8,206
Gunnison River (Above Blue Mesa)	4.25 2/	1.02 5/	25.1 6/	20,787	27,753	30,303	4,989	6,661	7,273
Ohio Creek	4.25 3/	1.02 5/	21.8 7/	35,595	45,518	61,243	8,543	10,924	14,698
Tomichi Creek	3.92 4/	0.94 5/	25.1 6/	48,710	65,033	101,175	11,680	15,595	24,261
Cochetopa Creek	3.92 2/	0.94 5/	25.1 6/	16,794	22,422	39,984	4,027	5,377	9,588
Quartz Creek	3.92 4/	0.94 5/	25.1 6/	7,399	9,878	9,878	1,774	2,369	2,369
Lake Fork Creek	4.25 2/	1.02 5/	25.1 6/	5,093	6,800	6,800	1,222	1,632	1,632
Cebolla Creek	4.25 2/	1.02 5/	25.1 6/	14,643	19,550	19,550	3,514	4,692	4,692
Soap Creek	4.25 2/	1.02 5/	25.1 6/	1,273	1,700	1,700	306	408	408
Taylor River	3.92 2/	0.94 5/	25.1 6/	1,057	1,411	1,411	253	338	338
Big Blue	4.25 2/	1.02 5/	25.1 6/	3,183	4,250	4,250	764	1,020	1,020
Crystal Creek	4.25 2/	1.02 5/	25.1 6/	2,005	2,678	2,678	481	643	643
Subtotal				178,031	235,687	313,193	42,708	56,539	75,128
Bostwick Park Project									
Bostwick Park Area	5.14 8/	1.44 5/	2.7 9/	14,614	15,013	21,588	4,094	4,208	6,048
Cedar Creek Area	3.43 8/	1.44 5/	2.7 9/	728	748	792	305	314	333
Shinn Park & Kinikin Heights Area	4.64 8/	1.44 5/	2.7 9/	7,553	7,763	8,969	2,344	2,409	2,784
Cimarron Area	3.60 8/	1.44 5/	2.7 9/	7,499	7,708	8,082	3,000	3,083	3,233
Subtotal				30,394	31,237	39,431	9,743	10,014	12,397
Uncompahgre									
South Canal	5.11 10/	1.80 5/	2.3 11/	35,047	35,872	36,690	12,345	12,636	12,924
West Canal	5.11 10/	1.80 5/	2.3 11/	28,707	29,383	30,047	10,112	10,350	10,584
M&D Canal	5.11 10/	1.80 5/	2.3 11/	126,060	129,028	131,991	44,405	45,450	46,494
Loutzenhizer Canal	5.11 10/	1.80 5/	2.3 11/	30,953	31,682	32,397	10,903	11,160	11,412
Selig Canal	5.11 10/	1.80 5/	2.3 11/	49,725	50,896	52,071	17,516	17,928	18,342
Ironstone Canal	5.11 10/	1.80 5/	2.3 11/	112,580	115,231	117,837	39,656	40,590	41,508
East Canal	5.11 10/	1.80 5/	2.3 11/	38,292	39,194	40,062	13,488	13,806	14,112
Garnet Canal	5.11 10/	1.80 5/	2.3 11/	7,938	8,125	8,329	2,796	2,862	2,934
Non-project lands within project boundaries	5.11 10/	1.80 5/	2.3 11/	39,940	40,880	40,880	14,069	14,400	14,400
Log Hill Mesa	3.12 12/	1.25 5/	19.8 13/	1,551	1,934	24,430	622	775	9,788
Dallas Creek / Colona	3.12 12/	1.25 5/	19.8 13/	18,642	23,244	23,244	7,469	9,313	9,313
Cow Creek	3.12 12/	1.25 5/	19.8 13/	8,257	10,296	10,296	3,308	4,125	4,125
Subtotal				497,693	515,763	548,274	176,689	183,395	195,935
TOTAL				706,118	782,687	900,898	229,141	249,947	283,460

1/ From Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Table 37, page 46.
2/ Weighted average diversion requirement from Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Tables 36, 37, and 38, page 46.
3/ From Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Table 38, page 46.
4/ From Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Table 36, page 46.
5/ From Blainey-Criddle consumptive use study, November 1987.
6/ Weighted average irrigation shortage from Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Tables 45, 46, 47, and 48, pages 60,68, 75, and 81.
7/ From Upper Gunnison Concluding Report, Water Supply Appendix, August 1973, Table 48, page 81.
8/ From Bostwick Park Definite Plan Report, Supplemental Water Supply Appendix, September 1965, Tables 10-13, pages 35-38.
9/ From Bostwick Park Definite Plan Report, Supplemental Water Supply Appendix, September 1965, Table 16, page 55.
10/ From Uncompahgre Project History, 1984, Volume 76. Value derived from average annual delivery 1980-84.
11/ From Dallas Creek Definite Plan Report, Water Supply Appendix, November 1976, Table 76, page 21.
12/ From Dallas Creek Definite Plan Report, Water Supply Appendix, November 1976, Tables 29 and 30, page 63.
13/ From Dallas Creek Definite Plan Report, Water Supply Appendix, November 1976, Table 40, page 69.

The livestock population projections are based on maintaining the historical ratio of livestock population per irrigated acre since the majority of these crops provide the food base for livestock production within the study area. Livestock population data were not available for individual subbasins within the study area, therefore, county-wide historical livestock data, along with the irrigated acreage estimates for each county in the study area were used to calculate these ratios. These ratios were then applied to the increased irrigated acreage that would occur under the moderate and high growth scenarios. The resulting livestock population projections are presented in Table 8.15. The livestock water demands computed based on the population projections are presented in Table 8.16. These demands are conservative since they include entire county population data even though portions of four of the six counties (Montrose, Delta, Hinsdale, and Saguache) are outside the study area. Table 8.16 shows that the forecasted consumptive use for livestock varies from approximately 1100 af per year to 1300 af per year under the baseline and high growth scenarios, respectively.

TABLE 8.14

Daily Water Requirements and Consumptive Use Rates (1)

Livestock Type	Average Daily Intake (gpcd) (2)	Average Daily Consumptive Use (gpcd)
Beef Cattle	9.0	5.2
Sheep	1.0	0.7
Hogs	2.0	0.9

(1) From Colorado State University, Cooperative Extension Service, Tri-River Area Extension Office, Delta, Colorado.

(2) gpcd - gallons per capita day.

TABLE 8.15

Livestock Population Projections

Livestock Type	Delta County	Gunnison County	Hinsdale County	Montrose County	Ouray County	Saguache County	Six County Total
(1) Cattle							
1984	40,000	38,000	2,000	62,000	12,000	32,000	186,000
1985	38,000	37,000	2,000	58,000	10,000	32,000	177,000
1986	37,000	35,500	2,000	56,000	9,000	31,500	171,000
Average	38,333	36,833	2,000	58,667	10,333	31,833	178,000
Ratio of Cattle to Irrigated Acreage							0.65
Projected Moderate Growth							186,808
Projected High Growth							206,356
(1) Sheep							
1984	16,600	14,200	0	52,000	3,500	6,000	92,300
1985	13,800	13,300	0	45,100	3,400	4,500	80,100
1986	13,500	11,000	0	45,000	3,400	3,400	76,300
Average	14,633	12,833	0	47,367	3,433	4,633	82,900
Ratio of Sheep to Irrigated Acreage							0.30
Projected Moderate Growth							87,002
Projected High Growth							96,106
(1) Hogs							
1984	2,300	0	0	7,000	0	0	9,300
1985	2,600	0	0	5,000	0	0	7,600
1986	4,000	0	0	5,500	0	0	9,500
Average	2,967	0	0	5,833	0	0	8,800
Ratio of Hogs to Irrigated Acreage							0.03
Projected Moderate Growth							9,235
Projected High Growth							10,202

(1) From Colorado Agricultural Statistics Service, 1986.

TABLE 8.16

Livestock Water Demands

Livestock Type	Gross Requirements			Consumptive Use		
	Base-line (af/yr)	Moderate Growth (af/yr)	High Growth (af/yr)	Base-line (af/yr)	Moderate Growth (af/yr)	High Growth (af/yr)
Beef Cattle	1,795	1,883	2,080	1,037	1,088	1,202
Sheep	93	97	108	65	68	75
Hogs	20	21	23	9	9	10
Totals	1,908	2,001	2,211	1,111	1,165	1,287

8.5 DEMAND FOR RECREATION

An important goal of this study is to identify ways and means of improving water-based recreational opportunities in the study area. Therefore, an estimate of the future demand for various types of recreational activities which presently take place or which could be developed in the study area was undertaken.

8.5.1 Methodology

The demand for any type of recreation activity is a result of how many people choose to participate and how often. Those choices are strongly influenced by the following factors: disposable income, cost of participation, amount of leisure time available, age, quality of the experience offered and the types of recreation activities the individual participated in as a child.

Although outdoor recreation demand is based on personal choice and is affected by economic conditions, experience in Colorado has generally proven that as new opportunities are developed, they quickly become utilized. This is especially true with facilities which offer a quality experience. Thus, development of quality outdoor recreation facilities which provide activities that have shown strong growth trends have a high probability of being utilized.

The methodology utilized in this study to estimate the demand for outdoor recreation is qualitative in nature. It consists of reviewing previously prepared forecasts; evaluating National, state and local trends; and considering known factors which affect recreation usage in order to arrive at a qualitative assessment of the demand for facilities in the study area. Two important underlying assumptions are:

- Proposed recreation facilities in the study area will not be priced so high as to retard demand.
- Facilities will be constructed as demand increases and therefore demand will not be limited by availability of facilities.

8.5.2 Results

After reviewing existing demand projections, historic recreation use trends and the factors which influence recreation user's decisions, the following conclusions were reached:

- The national growth of outdoor recreation has slowed in recent years but the present rate is between three and four percent which is indicative of strong growth.
- A continued long-term steady growth of three to four percent is expected nationwide. Short-term slow growth or even declines will occur as a result of short-term economic downturns. The

distribution of participants among various outdoor recreation activities will change as the age distribution of our population changes.

- Tourism and recreation are projected to continue to grow at a significant rate in Colorado.

- Cold water fishing is projected to increase at the rate of one and one-half to two percent nationwide.

- Fishing license sales in Colorado are projected to increase at the rate of about three percent from the present to the year 2000.

- The USFS projects an increase in visitation of 2.7 percent per year at their facilities in the study area.

- Considering the factors which affect recreation participants' choices, the study area is very attractive to potential recreation participants.

- The water-based recreation activities which are projected to have future high growth rates are: fishing, whitewater boating and wind surfing. Non-consumptive wildlife recreation activities, camping and hiking are also projected to have high growth in the future.

Based on the above, it appears that if new, high-quality recreation opportunities are developed, managed properly and publicized, a demand will exist and the facilities will be utilized to a high degree.

8.6 Recreation-Related and Other Water Demands

Recreation-related and other water demands are classified into four major areas:

- o potable water supplies at recreation facilities
- o water required for snowmaking at ski areas
- o instream flows required for a quality fishing, rafting, kayaking or outdoor experience
- o instream flows for other purposes

8.6.1 Potable Water Supplies

Many of the existing campground and recreation sites provide a potable water source to the visitor. The primary source of the water supply is groundwater. The majority of the supplies are untreated groundwater from wells located adjacent to streams. The present total demand for potable water at campgrounds is estimated to be approximately 75 af per year. Less than 30 percent of that demand is consumptively used. It is expected that future water demands at campgrounds could double or triple. The present and projected future demands is very small compared to the total water demand in the study area and therefore was not included in the hydrologic modeling effort to determine the adequacy of existing supplies within the basin to meet future demands.

8.6.2 Water For Snowmaking

The Crested Butte Mountain Resort uses approximately 30 af of water per year for snowmaking at present. With the proposed North Mountain expansion, the future demand for water for snowmaking will be approximately 60 af per year. Practically all of the water used for snowmaking returns to the streams during the spring thaw. Snowmaking requirements are relatively small in relation to overall basin water use but diversions take place during the low streamflow periods and therefore are included in the hydrologic model.

8.6.3 Streamflow Enhancement for Fisheries

This section discusses the potential enhancement of streamflows for fisheries and presents an estimate of desirable flow conditions for fishery

habitat. The term "desirable flow condition for fishery habitat" as used in this report is defined as the flow which is near optimum for the proposed fishery enhancement. It should be noted that the "near optimum" flows discussed herein are flows that will ensure fish habitat for an excellent fishery over a long term. This is significantly different from the minimum instream flows estimated by the CWCB which in many instances are between a survival and a maintenance streamflow associated with an existing fishery.

The results presented in this section are considered target values which were used when sizing non-structural and structural components in an effort to provide these flows. After estimating the magnitude of the components required to provide streamflow enhancement, the practicality of including such components in project plans was evaluated from the standpoint of technical and economic feasibility. It should be noted that institutional constraints must be addressed before a program of streamflow enhancement can be carried out. For example; if storage in a reservoir is provided for streamflow enhancement, the question of how the releases will be protected under existing water rights administration must be resolved. It should also be noted that under Colorado law, the CWCB is the only entity authorized to make instream flow appropriations. It should be stressed, therefore, that the target streamflow enhancements identified in the following sections have been estimated without consideration of economic and institutional factors. Economic considerations related to meeting these targets are addressed in Chapter 14.0 of this report. However, the institutional factors will not be addressed until later phases of this study.

The optimum streamflow for fish habitat is not a static value but is different at different times of the year. It also varies with the species of fish and with the average size of the fish present in the fishery. In general, the cycles of flow to support trout should include:

- Flushing flows of a magnitude to cleanse the stream's gravel beds of accumulated silt and sediment but not so high as to cause bank erosion and degradation.

- o A minimum flow which results in maximum habitat as expressed in terms of an acceptable range of depth, velocity and wetted perimeter for the resident species.

- o A relatively stable flow regime during periods of spawning and egg hatching.

Minimum instream flow requirements for fish, wildlife, other aquatic organisms, recreation and aesthetics have been under study by universities, state and Federal agencies, since the early 1970's. As a result, numerous methodologies for the determination of minimum instream flows have been developed. Most of these methodologies are based on collection and analysis of field data but several are strictly "office" methods which utilize published streamflow data and empirical relationships. It is generally accepted that the more rigorous methods based on field data collection are required for project level, site specific studies and that office methods are acceptable for preliminary assessments at the regional planning and reconnaissance level phase of study (Wesche and Rechard, 1980). After evaluating the applicability of the various methods to this study (considering its prefeasibility level, the large study area and schedule limitations), the Tennant Method (Tennant, 1975), which is an office method, was selected. The basis of the Tennant Method is presented in Table 8.17.

The "desirable" streamflow was selected from Table 8.17 as the Recommended Base Flow Regime corresponding to the Excellent classification of flow. This results in target streamflows of 50 and 30 percent of average annual discharge in summer and winter, respectively. A year-round flow of 30 percent of average annual discharge was selected as the minimum streamflow for fishery enhancement purposes in instances where the targets cannot be met because of insufficient hydrologic yield. A preliminary hydrologic evaluation was made for each candidate fishery enhancement stream and it was determined that natural flows were usually not adequate to meet the recommended values and that storage would be required to provide streamflow enhancement. The targets established above were utilized to size in-basin reservoirs and to

evaluate their performance by the basin hydrologic model. This is discussed in Chapter 13.

8.6.4 Streamflow Requirements for Whitewater Rafting

Commercial rafting opportunities in the study area exist on the Taylor River between the confluence with Lottis Creek and the confluence with the East River; on the Gunnison River between the confluence with the Taylor River and Blue Mesa Reserovir; and on the Lake Fork of the Gunnison River between Ryan's Bridge (seven miles north of Lake City) and Blue Mesa Reservoir. Discussions were held with commercial rafters in order to obtain their assessment of optimum and minimum flows required for rafting each of these three streams. In instances where rafters did not have knowledge of actual flows, they were asked to characterize times of specific years when flows were excellent, minimal or unsuitable for rafting. Streamflow records for those periods were then reviewed to determine the corresponding flows in the river.

TABLE 8.17

Instream Flow Regimens for Fish, Wildlife, Recreation and Related Environmental Resources

Narrative Description of Flows 1)	Fisheries Class 2)	Recommended Base Flow Regimens (Percentage of Average Flow) Oct-Mar	Apr-Sept
Flushing or Maximum	--	200 3)	200 3)
Optimum Range	--	60-100 4)	60-100 4)
Outstanding	I	40	60
Excellent	II	30	50
Good	III	20	40
Fair or Degrading	IV	10	30
Poor	--	10	10
Severe Degradation	--		

1) Most appropriate description of the general condition of the streamflow for all parameters listed in the title of the table.

2) Roman numeral ratings for Fisheries Classification Systems like those developed for the states of Idaho, Montana, West Virginia, Wyoming, and the Delaware River Basin Comprehensive Study by the U.S. Fish and Wildlife Service. The base flow regimens outlined above in columns 3 and 4 to maintain the respective designated classes, are judged to be as reliable and valid as the classification systems themselves. These recommended flows generally apply very well to both cold and warm water streams. Regimens should be reversed or altered to fit different hydrologic cycles, like the Salmonid streams on the West Coast, or to favor species like the fall spawning brown trout. Flows may be refined further by specifically matching them to vital periods of the life cycle of fishes, like migration, spawning, incubation, growth, etc. Use of the Montana Method on spring creeks or streams that have a very uniform flow year-around may provide unprecedented low-flow regimens at the minimum or base flow levels.

3) The average flow will usually fill the active stream channel approximately 1/3 full or to the line of permanent terrestrial vegetation, while three times the average flow will often fill the active channel approximately to the point of spilling out on the first bench of the flood plain. Twice the average flow will produce effective depths and velocities within the stream channel for moving silt, sediment and other bed load material without doing extensive damage to the banks and riparian vegetation. Twice the average flow is a good maximum flow recommendation as well as a good flushing flow.

4) Optimum is a nebulous term; however, this flow range covers that definition best for all the parameters of this paper, collectively.

Source: Tennant, 1975 (Table reproduced in its entirety and therefore certain wording may not be applicable to this report.)

The Gunnison River between Almont and Blue Mesa Reservoir is considered by commercial rafters to be a scenic river suited to fishing and leisure rafting. Flows in the Gunnison are rarely too low for these purposes from the customer's perspective. However, operators curtail operations periodically during low flow periods in order to minimize damage to their craft.

Discussions were held with commercial rafters operating on the Taylor River to obtain their insight into flow conditions. The following observations provided by them relate to flows at the Taylor River gage located at Almont. Optimum flow for whitewater rafting on the Taylor River is reported to be approximately 1000 cfs. The minimum flow for a good rafting experience for the entire stretch below Crystal Creek is reported to be approximately 600 cfs. When flow at the Almont gage drops below about 400 cfs, the reach of river near the confluence of Spring Creek becomes too shallow for clear passage requiring dragging of the craft over low spots. Analysis of this information and correlation of rafting shut-down dates with flow records indicates that the flows cited by the rafters may be slightly overstated. The results of this preliminary analysis indicates that the minimum release from Taylor Park Reservoir for a quality rafting experience on the Taylor River is on the order of 300 cfs (approximately 400 cfs at Almont). It should be noted, however, that rafting is still possible at lower levels of Taylor Park Reservoir releases but the quality of the experience is lessened. Further evaluation is required to verify this figure and also to define critical reaches where streambed modifications may provide greater benefit than increased streamflows.

Rafting on the Lake Fork of the Gunnison is not as developed as on the other streams and data is not available on the optimum rafting flows. The minimum flow for rafting is estimated to be approximately 350 cfs which generally occurs in late July. The rafting season usually ends by the first of August and some means of streamflow enhancement would be required in order to extend the rafting season.

8.6.5 Instream Flows for Other Purposes

In addition to recreation related instream flow demands, instream flow requirements related to Federal reserved water rights, minimum instream flow rights held by the Colorado Water Conservation Board, privately held minimum instream flow rights and endangered species flow rights could also have a significant impact on potential water development projects in the basin. These non-consumptive water demands and their treatment in developing the hydrologic model were discussed previously in Chapter 7.0.

8.7 POWER DEMAND AND MARKET VALUE FORECASTS

Considering the long lead time required to plan, design, permit and construct power facilities, a comparison of estimated future demand with existing and planned supply is required to decide whether additional projects should be pursued in order to ensure that future demands will be met. For that reason, a preliminary assessment was made of the demand for hydroelectric power. The assessment consists of two parts; an evaluation of the potential demand for hydropower, and an estimate of the future market value of power. The objective of undertaking this preliminary assessment was to evaluate whether future power demands could absorb power production from a potential project within the study area. It is stressed, however, that a strong demand scenario may result in a larger number of competing proposals. Final selection of projects to be developed will be made by the marketplace based on economics and timing of availability of alternatives.

Projections of the future demand for power in Colorado and the western region have been prepared by numerous public and private authorities. Several of these forecasts have been reviewed and were used as the basis for preparing the present forecast. The following discussion will focus on: the potential market area for power and energy generated by project facilities; the forecast of near-term and long-term power demands during the planning horizon of 1985-2035; planned capacity additions; and the value of power.

8.7.1 Existing Power Market

The two primary electric utilities operating within the study area are the Colorado Ute Electric Association (Colorado Ute), which is comprised of 14 distribution cooperatives that serve specified areas; and the Western Area Power Administration (WAPA), which is a Federally-owned agency whose purpose is to market power generated by Federal hydroelectric facilities. Because of its ties with the Federal government, WAPA would be a potential market only for hydroelectric power generated by new facilities which utilize existing features owned by the Federal government.

Colorado Ute owns and operates about 15 percent of Colorado's generating capacity (CPUC, 1987), most of which is derived from coal-fired thermal plants. Member associations of Colorado Ute operating within the study area include the Delta-Montrose Electric Association, the Gunnison County Electric Association, and the San Miguel Power Association. Colorado Ute is considered a potential market for power. However, the member associations are not, because their existing "all requirements" contracts with Colorado Ute preclude them from producing power or purchasing it from other sources. In addition to Colorado Ute, the cities of Gunnison and Delta operate municipally-owned distribution systems using power supplied by Colorado Ute and WAPA. Both are considered to be a possible market for power although their respective loads are relatively small.

There are a number of other utilities operating within the state which might provide a possible market for power generated within the study area. The largest of these is the Public Service Company of Colorado (PSC), an investor-owned system which owns nearly half of the state's generating capacity (CPUC, 1987). Other major utilities include the Platte Power Authority, an association of municipalities which serves a portion of northeastern Colorado; Tri-State Generation and Transmission, a cooperatively-owned utility which serves northeastern Colorado and portions of Wyoming and Nebraska; Central Electric-Colorado, an investor-owned system serving the Pueblo, Canon City, and Rocky Ford areas; and the City of Colorado

Springs, a municipally-owned system. These utilities are members of the Rocky Mountain Power Area (RMPA), which is part of the Western Systems Coordinating Council (WSCC).

In 1985 the system peak demand for power within the State of Colorado was estimated by the Colorado Public Utilities Commission (CPUC) to be 4898 MW, and that peak was projected to occur during the winter to meet residential, commercial and industrial needs. Peak summer demand during 1985 was estimated to be slightly less, 4761 MW. The available generating capacity to meet these demands totalled 6627 MW during summer operating conditions and 6893 MW during winter operating conditions. Approximately 70 percent of this capacity is provided by fossil-fueled steam-electric plants. About 14 percent of this capacity is provided by conventional and pumped storage hydro facilities, over two-thirds of which is operated by WAPA (CPUC, 1987).

The difference between peak capacity and peak demand is termed reserve margin. Some measure of reserve margin is required to allow for increases in demand, generation outages, firm purchase capacity outages and a severe weather allowance. A reserve margin on the order of 15 to 20 percent is considered to be adequate for the utilities in Colorado, especially in light of past and projected low local growth rates in the state. The present statewide reserve capacity is 28.1 percent, which indicates an oversupply of generating capacity within the state at present.

The proximity of the study area to New Mexico, Utah and Arizona would indicate that utilities serving these states may also represent a possible market for power and energy generated by new facilities within the Gunnison Basin. However, because the Gunnison Basin baseload facilities are likely to be small (less than 50 MW), it was assumed that other projects could be developed within these service areas which would meet their needs more economically. Therefore, the demand for baseload power and energy in areas outside of Colorado was not considered or evaluated for this study. Adjacent states would be a potential market for peaking power.

8.7.2 Power Demand Forecasts

Power demand varies and is dependent upon a large number of demographic, economic and climatic factors. However, the principal elements which drive power demand are population, per capita income, presence of energy intensive industries, the number of households served by a utility, and the price of electricity relative to natural gas. These elements combined with others such as time of day, day of week, outside temperature, etc., create a demand for electricity which varies hourly, daily and seasonally.

Demand forecasts are typically prepared using historical trends of power and energy usage, or by using mathematical models which incorporate projected trends of the elements which affect power and energy demand. Because these forecasts attempt to project future conditions, they are subject to unanticipated events which may change, perhaps dramatically, the projected values of power and energy demand. These uncertainties diminish the reliability of the projected demands as the forecast period is lengthened. This is the reason that utilities generally prepare forecasts for a 10 to 20 year period and update them annually. In order to maximize the use of existing data, it was decided to prepare near- and long-term forecasts which were combined to form the forecast for the 50-year planning horizon.

8.7.2.1 Near-Term Demands

Near-term demands are defined for this study as the demands for electricity which can reasonably be expected to occur during the period 1985 through 1996. This time frame was selected for compatibility with existing forecasts prepared by the CPUC. The CPUC forecast was accepted as the near-term forecast for use in this study. It should be noted that no attempt was made to verify the CPUC forecast.

Table 8.18 presents data taken from the Colorado Electric Supply Survey (CPUC, 1987) for the three Colorado Ute members and two municipalities operating electric distribution systems within and adjacent to the Study Area.

This data is indicative of electrical demand growth in the study area and areas immediately adjacent thereto. The combined peak demand within the area served by these five utilities totalled 111 MW in 1985 and is expected to increase to 171 MW in 1995, a compound annual rate of 4.4 percent. The Gunnison County Electric Association (GCEA) is predicted to have the highest growth rate in the study area increasing from 22 MW in 1985 to 40 MW in 1995. The GCEA growth rate appears to be optimistic but verification of it is not within the scope of the present study.

Demand forecasts for the State of Colorado are presented in Table 8.19. From this table it can be seen that compound annual growth rates range from 1.2 percent for the Arkansas Power Authority to 4.6 percent for the Platte River Power Authority. Statewide, CPUC forecasts a 2.5 percent growth rate in winter peak demand and this figure was accepted as the near term demand forecast.

TABLE 8.18

Study Area Near-Term System Demand in Megawatts

Electric utility	1985 (actual)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Compound annual growth rate
Delta Montrose Elec. Assoc.	54	61	67	70	74	76	78	79	81	85	86	
Annual percentage change		13.0%	9.8%	4.5%	5.7%	2.7%	2.6%	1.3%	2.5%	4.9%	1.2%	4.8%
Gunnison County Elec. Assoc.	22	24	29	30	31	33	35	36	37	38	40	
Annual percentage change		9.1%	20.8%	3.4%	3.3%	6.5%	6.1%	2.9%	2.8%	2.7%	5.3%	6.2%
San Miguel Power	20	23	23	23	24	24	24	25	25	25	25	
Annual percentage change		15.0%	0.0%	0.0%	4.3%	0.0%	0.0%	4.2%	0.0%	0.0%	0.0%	2.3%
Gunnison Municipal System	9	10	10	10	10	11	11	11	12	12	12	
Annual percentage change		11.1%	0.0%	0.0%	0.0%	10.0%	0.0%	0.0%	9.1%	0.0%	0.0%	2.9%
Delta Municipal L & P	6	6	6	6	6	7	7	8	8	8	8	
Annual percentage change		0.0%	0.0%	0.0%	0.0%	16.7%	0.0%	14.3%	0.0%	0.0%	0.0%	2.9%
Total study area demand	111	124	135	139	145	151	155	159	163	168	171	
Annual percentage change		11.7%	8.9%	3.0%	4.3%	4.1%	2.6%	2.6%	2.5%	3.1%	1.8%	4.4%

Source: Colorado Public Utilities Commission, 1987. "Colorado Electric Supply Survey, 1985 - 1995."

TABLE 8.19

Statewide Near-term Peak Demand in Megawatts

Electric utility	1985 (actual)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Compound annual growth rate
INVESTOR OWNED:												
Home Light & Power	110	110	113	115	118	120	123	126	128	131	134	2.0%
Public Service Co.	2724	2757	2838	2927	2975	3044	3156	3236	3321	3407	3498	2.5%
Southern Colo. Power	185	188	191	194	197	200	203	206	209	212	215	1.5%
Subtotal, Investor owned	3019	3055	3142	3236	3290	3364	3482	3568	3658	3750	3847	2.5%
Winter coincident peak	2996	2971	3045	3102	3147	3191	3244	3312	3392	3459	3547	1.7%
Summer coincident peak	2933	2981	3069	3164	3218	3291	3408	3493	3582	3673	3770	2.5%
COOPERATIVELY OWNED:												
Tri-State G & T	575	566	585	592	604	614	625	634	645	655	663	1.4%
Colorado Ute Elec. Assoc.	759	786	834	865	911	946	986	1017	1052	1092	1103	3.8%
Other REA's	68	74	84	85	86	93	101	104	107	109	112	5.1%
Subtotal, Cooperatively owned	1402	1426	1503	1542	1601	1653	1712	1755	1804	1856	1878	3.0%
Winter coincident peak	1076	1060	1111	1162	1204	1267	1304	1349	1397	1447	1502	3.4%
Summer coincident peak	1075	1069	1115	1159	1200	1247	1291	1328	1368	1411	1456	3.1%
MUNICIPALLY OWNED:												
Colorado Springs	455	479	505	532	557	581	604	625	645	666	687	4.2%
Arkansas River PA	57	57	56	57	58	59	60	61	63	64	64	1.2%
Platte River Power Authority	235	249	274	285	298	310	320	331	345	358	369	4.6%
Other Municipals	86	89	90	94	96	101	102	106	111	114	119	3.3%
Subtotal, Municipally owned	833	874	925	968	1009	1051	1086	1123	1164	1202	1239	4.1%
Winter coincident peak	823	863	914	955	994	1032	1068	1104	1140	1175	1213	4.0%
Summer coincident peak	750	802	855	892	933	971	1008	1044	1079	1114	1147	4.3%
WAPA Direct sales												
Winter peak	3	3	3	3	3	3	18	18	18	18	18	19.6%
Summer peak	3	3	3	3	3	3	18	18	18	18	18	19.6%
Total statewide coincident peak demands												
Winter coincident peak	4898	4897	5073	5222	5348	5493	5634	5783	5947	6099	6280	2.5%
Summer coincident peak	4761	4855	5042	5218	5354	5512	5725	5883	6047	6216	6391	3.0%

Source: Colorado Public Utilities Commission, 1987. "Colorado Electric Supply Survey, 1985 - 1995."

8.7.2.2 Long-Term Demands

Long-term demands are defined for this study as the demands for electricity which can reasonably be expected to occur during the period 1996 through 2035. This time frame was selected for compatibility with demographic and water demand forecasts for the study area.

Long-term power demands are difficult to forecast with certainty because of the many variables which influence demand. Consequently, relatively little information exists regarding projections this far into the future.

The Edison Electric Institute (EEI, 1986) compiled statistics from 14 power demand forecasts for the United States. The results of these forecasts varied widely depending on the assumptions regarding future economic conditions. Projections of future power demand growth rates ranged from 0.8 percent per annum (National Audobon Society, 1984) to 4.5 percent (Siegel and Sillin, 1984). The U.S. Energy Information Administration (1984) suggests a compound annual growth rate of 2.8 percent.

Long-term economic forecasts indicate that Colorado may experience employment growth of 1.5 to 2.0 percent over the planning horizon. The present low value of the United States dollar compared to other foreign currencies is expected to continue in the future (Wharton, 1987). That should lead to strong exports of agricultural production and manufactured goods. Colorado's share of the high tech industry is expected to grow in the future and statewide tourism should also continue to be a strong segment of the state's economy.

Based on available long-term power demand forecasts which range up to 4.5 percent per annum in conjunction with relatively strong future economic indicators for the state, an average long-term compound annual growth of 2.5 percent is considered realistic for power demand in the state and was used.

8.7.3 Planned Capacity Additions to Meet Demands

According to the Colorado Electric Supply Survey, 1986-1995, the total generating capacity available to Colorado utilities was 6627 MW in the summer and 6893 MW in the winter (CPUC, 1987). The majority of this capacity is produced by coal-fired steam-electric plants. The estimated reserve margin in 1986 was 28.2 percent, indicating an oversupply of generating capacity.

The CPUC also forecasts that an additional 1500 MW will be brought on-line by 1995. Much of the additional capacity will be derived from cogeneration facilities developed by IPP. During the CPUC forecast period, it is projected that the Fort St. Vrain plant, Colorado's only nuclear-powered station, will be retired resulting in a loss of 230 MW. This loss is expected to be compensated for by the addition of PSC's Pawnee 2 Station, a 485 MW coal unit, and the Nixon 2 Station, a 350 MW unit proposed by Colorado Springs. The expected capacity additions available to Colorado utilities will, if developed as planned and growth occurs as forecasted, result in a reserve margin of about 22 percent in 1995.

Figure 8.3 depicts graphically the capacity additions planned by Colorado utilities and IPP through 1995, the projected demands for the study period (8.5 percent growth) and the generating capacity required to meet demands assuming a 15 percent reserve margin. If development and demand grow as predicted, available supplies will continue to exceed demand through about the year 2005, if infringement on the reserve margin is allowed to take place. If the 15 percent reserve margin is to be maintained, additional generating capacity will be required by the year 1997.

New hydropower development within the Gunnison Basin could be used to fulfill a portion of this need. However, these developments will compete with proposed hydropower developments in other basins of the state, some of which may prove to be more economical or less damaging to the environment.

8.7.4 Projected Baseload Market Values

The CPUC instituted a bidding system on January 1, 1989 for the sale of power by an independent power producer (IPP) to the Public Service Company of Colorado (PSC). Under this system, PSC will issue Requests for Proposals every two years and the IPP's will bid on the right to fill PSC's needs. This new system makes it very difficult to estimate the future value of power. For the purpose of this study, it was decided to use the avoided cost method to establish the value of baseload power. This approach is based on a comparative analysis of the cost of constructing and operating an alternative facility which could compete with a proposed hydro project.

The U.S. Bureau of Reclamation (USBR) analyzed the cost of a coal-fired baseload steam plant in January 1988. The results of that analysis are used by the USBR in planning studies as the avoided cost of power for establishing the value of power produced by proposed hydro facilities. The avoided cost figures presently (1988) used by the USBR are $17.83 per kW-month for capacity and 1.63 cents per kWh for energy, assuming Federal financing. Assuming private financing, the capacity figure increases to $24.08 per kW-month. These figures were accepted for use in this study.

Forecasts of these values into the future have not been made for several reasons. First of all, the present value of power is not firmly established. Secondly, small errors in projecting the future market value out to year 2035 could result in significant errors in the estimate of total project benefits. Only real price changes, exclusive of inflation, are of interest in the economic analysis. A constant real price (present market value) was used for future projected price levels to result in a conservative analysis.

8.7.5 Peaking Power Demands and Market Value

A separate study of the future demand and market value of peaking power has recently been completed by Stone & Webster Management Consultants, Inc., for the Colorado Water Resources and Power Development Authority (S&W, 1988).

That study assessed the economic potential of pumped-storage developments by integrating generic pumped-storage facilities into a statewide system expansion model. The model evaluates potential long-term avoided costs by comparing systems without and with pumped-storage additions. The model used for this effort was the Electric Power Research Institute's (EPRI), Electric Generation Expansion Analysis System (EGEAS).

The study evaluated the potential need for pumped-storage capacity through the year 2007 under three assumed peak load growth rates as follows: Low Load Growth, 1.95 percent; Medium Load Growth, 2.13 percent; and High Load Growth, 2.53 percent. The study concluded that for the medium peak load forecast, 450 MW of pumped storage might be added to utility systems with the first increment in year 2002. In the low peak load forecast scenario, only 75 MW is considered attractive and not until the year 2007. If the high peak load forecasts were realized, the amount of economic pumped storage capacity may be increased to 825 MW, with the first increments required as early as 1996.

It was also determined that pumped storage may be feasible for a wide range of costs (from $500 per KW to $1,480 per kW in 1988 dollars) depending on the utility system. For some systems pumped storage was not feasible during the 20-year study period because there was already enough existing capacity in the system; or the pumped storage unit was not competitive with the other resources that were available. The study results are summarized in Table 8.20.

TABLE 8.20

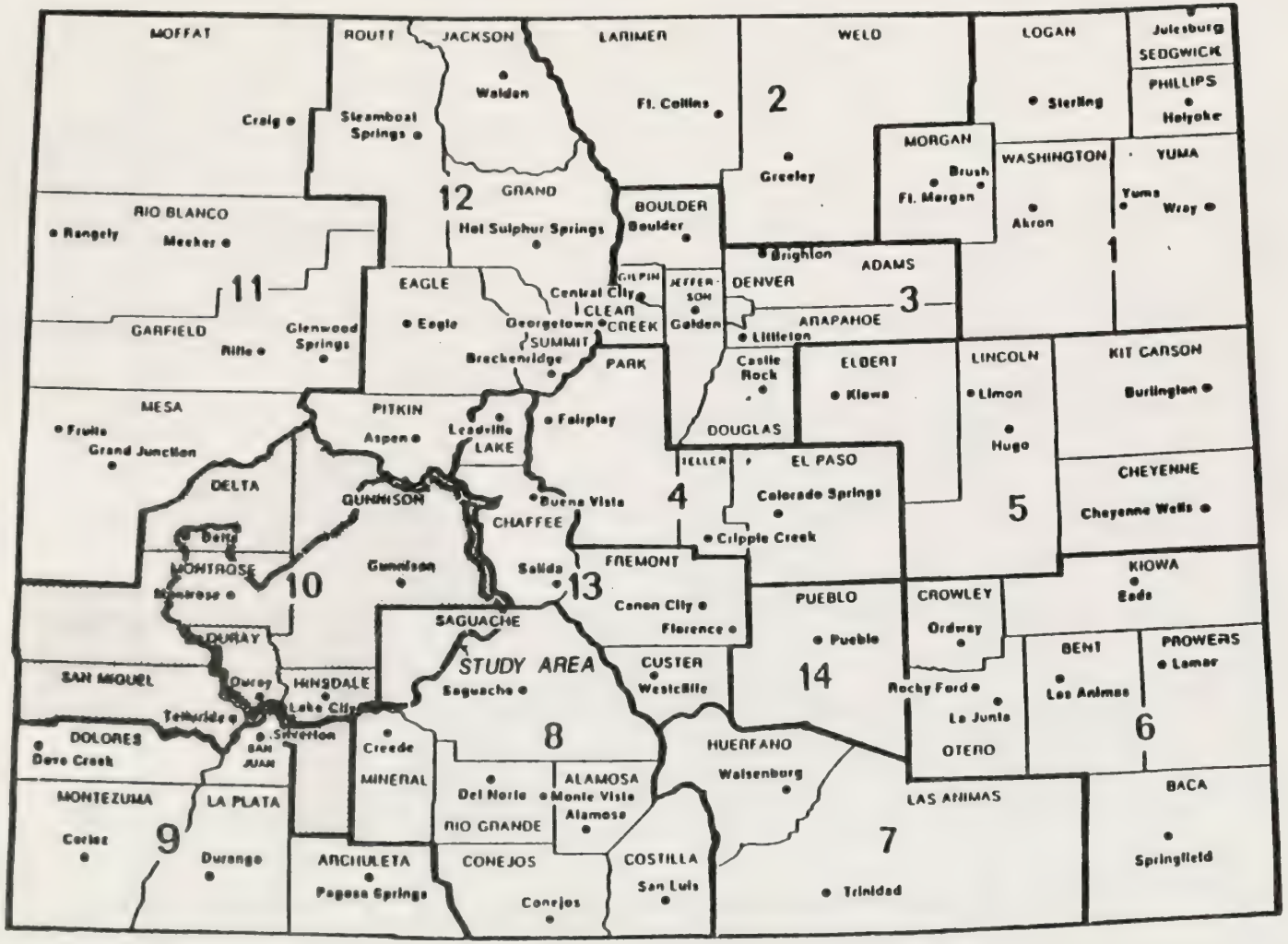
Amount of Pumped Storage Investment Cost
That May be Supported by System Operation - In 1988 $

Year	Low Load Growth Size (MW)	Low Load Growth $ per kW	Medium Load Growth Size (MW)	Medium Load Growth $ per kW	High Load Growth Size (MW)	High Load Growth $ per kW
1993	25(1)	540	25(1)	540	25(1)	500
					75(1)	1,020
1996					75(2)	1,020
1999					75	1,020
2001					75	1,480
					75	1,020
2002			150	1,230	75	1,480
2003					150	1,480
2004					75	1,020
2005			75	560		
			75	1,230		
2006			75	1,230	75	1,480
2007	75	670	75	1,230	150	1,480
Total	75		450		825	

(1) Resulting from individual utility expansion plans; however, with integrated system-wide operations 1993 needs could be met through inter-utility purchases of existing capacity. Therefore, the totals do not include those pumped storage additions in 1993.

(2) Selection of pumped storage planning criteria was based on 350 MW units. Therefore, the 75 MW additions are considered increments of larger projects that may be shared among utilities or whose additional capacity is sold out of state. Alternatively, future studies would have to evaluate any effects resulting from the use of smaller unit sizes.

Source: Colorado Joint Planning Study, Economic Potential of Pumped Storage, 1988, Stone & Webster Management Consultants, Inc.



SOURCE: State of Colorado, Division of Planning, 1974

LEGEND:

Region 10

Study Area Boundary

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

COLORADO PLANNING AND MANAGEMENT REGIONS

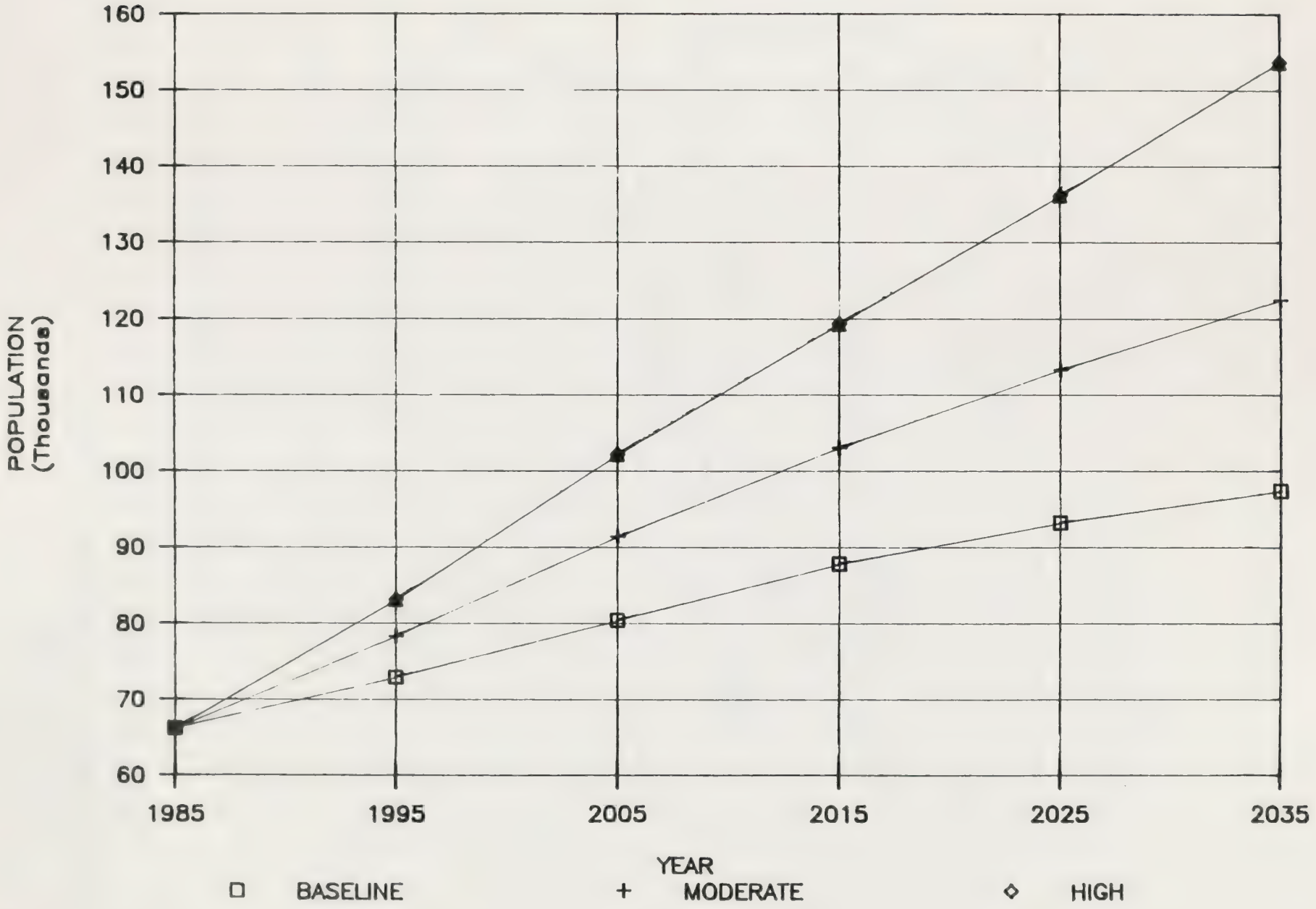
HDR ENGINEERING, INC.

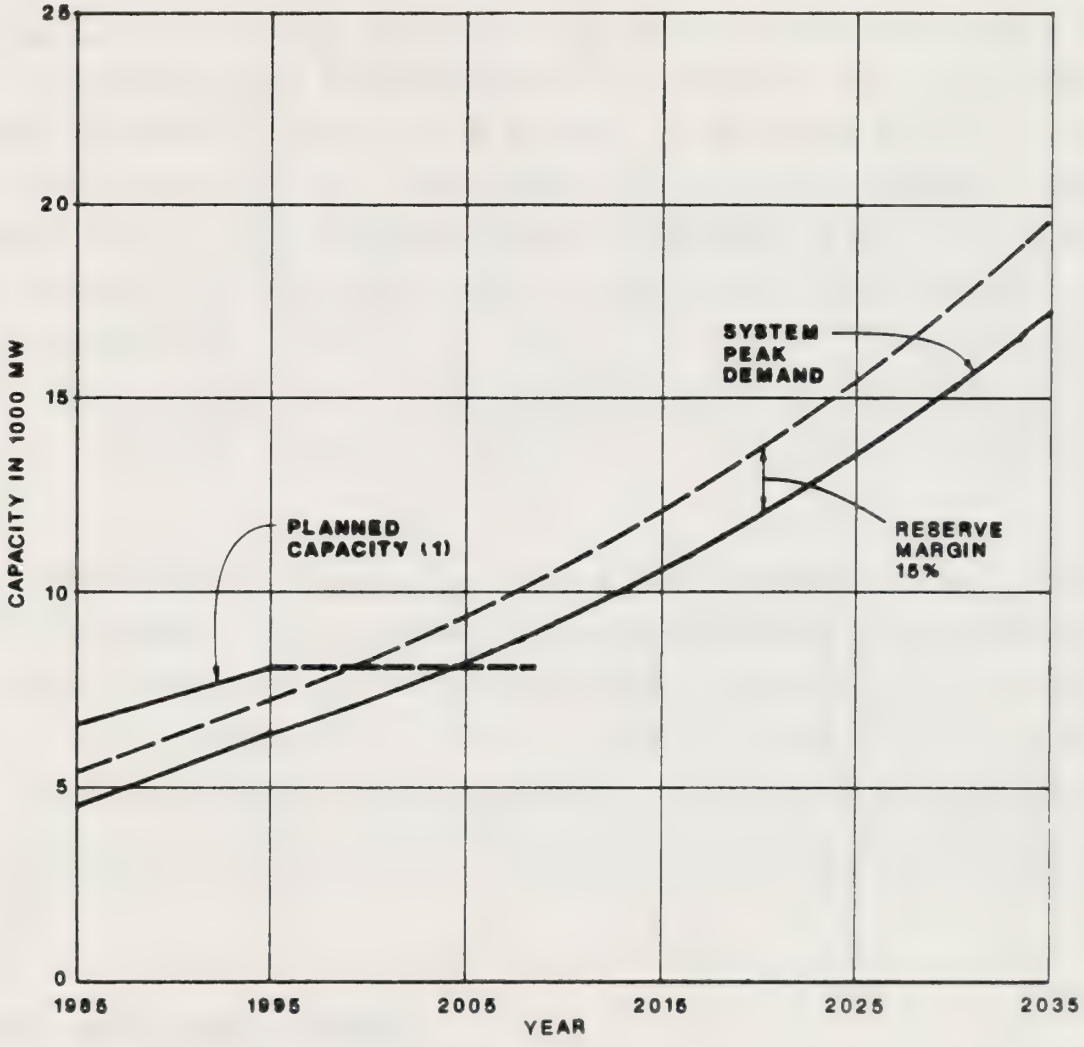
CU Center For Economic Analysis · WBLA, Inc
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE April 1989 FIGURE 8.1

FIGURE 8.2

POPULATION FORECASTS – REGION 10





(1) NOTE: Planned Capacity Data Unavailable After 1995.

COLORADO WATER RESOURCES
AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

**PLANNED CAPACITY
vs. FORCASTED DEMAND
STATE OF COLORADO**

HDR ENGINEERING, INC.
CU Center For Economic Analysis · WBLA, Inc
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE: April 1989 FIGURE: 8.3

9.0 COMPARISON OF EXISTING SUPPLY WITH FUTURE DEMANDS

9.1 INTRODUCTION

An evaluation was made to assess the ability of existing basin water supplies to meet projected future demands. The "current" level of basin water development includes all the existing projects in the basin as well as several projects which are not yet constructed. This latter category includes projects presently in the advanced stages of planning and some projects which might be developed in the future under existing conditional decrees. These potential projects are identified in Table 7.3 of this report. Although this condition contains some level of new development, it is termed the No-Action Alternative because it does not include any of the developments recommended by this study.

The evaluation was carried out using the hydrologic model described previously in Chapter 7.0. The model run for evaluating this condition was the first post-calibration use of the model and is referred to as Scenario 1. A number of system performance indicators were monitored for this scenario. These include: shortages to various demands; instream flow deficiencies; and reservoir storage contents. The remainder of this chapter describes these future water demand assumptions in more detail and presents the results of the model run.

9.2 FUTURE WATER DEMANDS MODELED

9.2.1 Municipal and Industrial Demands

The future municipal and industrial water demands explicitly represented in Scenario 1 are summarized in Table 9.1. The footnote to Table 9.1 describes the water rights which were assumed to support these demands.

TABLE 9.1
Future M&I Water Demands
No Development Scenario

Demand Area or Location	Model Node Number	Annual Diversion AF	Annual Depletion AF
Municipal and Domestic:			
Project 7 Water Authority[1]	111	10,194	3,058
Town of Crested Butte[2]	51	941	282
City of Gunnison[4]	43	4,033	1,900
City of Grand Junction[4]	4	25,554	25,554(2)
Industrial:			
Crested Butte mining[5]	51	640	120
Lake City mining[5]	27	640	120
Crested Butte Mtn Resort[3]	145	700	150
Snowshoe Reservoir (N. Fork)[6]	126	61,600	7,500
Paonia Refill (N. Fork)[6]	126	2,756	1,376
Lamm Reservoir (Lower Gunn.)[6]	4	22,000	22,000
TCWCD M&I Contract Sales[7]	133	20,924(1)	20,924(1)
Snowmaking:			
Crested Butte Mtn Resort[3]	145	1,008	302

(1) does not include 7176 AF used through the Project 7 Water Authority
(2) totally consumptive to basin of origin

Supporting Rights:
1 Ridgway M&I exchange
2 Current junior decrees with Curecanti subordination
3 Junior conditional decree with Curecanti subordination
4 Conditional decree senior to Blue Mesa
5 New water rights
6 Conditional decree junior to Blue Mesa
7 Ridgway M&I account remaining after Project 7 exchange

9.2.2 Agricultural Water Demands

The future agricultural water demands represented in this scenario are those which arise from provision of a full irrigation supply to currently irrigated lands. No new lands are assumed to be brought into production as part of this demand.

The full agricultural demands at aggregation points in the basin representing smaller irrigation rights were derived from estimates of potential irrigation consumptive use and current irrigated acreage at each point. Consumptive use values were provided by the USBR for several basin locations and cropping patterns; the derivation of these values is discussed in detail in the preceding chapter. The irrigated acreage estimates used are also presented in that chapter and are the same as were used in the development of virgin flows and in the allocation of aggregated depletions described in Chapter 7. The consumptive use values were translated into patterns of monthly depletions and allocated to priority classes using procedures described in Chapter 7.

Irrigation demands in the Uncompahgre Project were also derived from estimates of potential consumptive use and acreage irrigated under each canal. Surface and groundwater return flow demands were based on historical diversion rates. Full potential irrigation consumptive use was added to these return flow demands to arrive at the diversion requirement for each canal. Diversions into the Uncompahgre Project canals were constrained to be no less than historical levels.

In addition to these irrigation demands, one other agricultural demand was represented in this scenario. This demand arises as the result of development under the conditional decree held for the Fruitland Mesa Project. Depletions due to the Fruitland Mesa Project were derived from the Definite Plan Report and subsequent studies (USBR, 1977; PRC, 1980). The Project is assumed to divert and consumptively use 4056 af of water per year from the

Crystal Creek basin. These diversions benefit from the Curecanti subordination.

9.2.3 Instream Flow Needs

Instream flow demands were represented in Scenario 1 by the private and CWCB decreed and applied for instream flow rights described in Chapter 7.0. No new instream flow requirements or proposed enhancements were represented in this scenario. Shortages to these instream flow decrees reflect instream flow deficiencies which occur under future M&I and agricultural water demand conditions.

9.3 SYSTEM PERFORMANCE

The ability of the current levels of basin water resource development to meet future in-basin demands was assessed by examining the flows allocated to the various model arcs representing those demands. Whenever the flow in a demand arc is less than the capacity of that arc, a demand shortfall exists. The demand shortfalls which resulted from this model run are summarized in the following sub-sections. The contents of the principal basin reservoirs are also discussed.

9.3.1 Municipal and Industrial Demands

There are essentially no shortages to municipal and industrial water users in Scenario 1. The only shortages occurring were to the Crested Butte mining demand. These shortages, which occur in five years and average 38 af each, result from a combination of limited physical supply and a senior CWCB instream flow decree below the demand point.

Monthly flows diverted through the AB lateral hydropower facility under Scenario 1 are shown in Table 9.2. In Scenario 1, AB hydropower facility flows were limited to a maximum of 1100 cfs. This maximum is reached in many months.

TABLE 9.2

Flow Through AB Lateral Hydropower Facility
Scenario 1
Values in cfs

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1952	762	1058	1055	1089	1100	977	1060	842	802	493	693	708	885
1953	748	1081	1055	910	946	746	557	576	673	423	518	506	727
1954	786	990	1055	394	142	0	278	362	384	374	278	387	454
1955	220	0	0	330	42	17	530	447	480	333	267	198	240
1956	82	13	726	810	755	511	540	606	497	309	454	209	458
1957	480	952	1048	1089	1100	974	1037	811	850	780	877	802	898
1958	932	1100	1055	1089	1100	973	1025	808	806	454	570	669	880
1959	808	975	1055	672	454	158	449	512	526	383	403	300	559
1960	311	522	1055	905	929	741	877	697	816	409	396	585	685
1961	804	956	1024	630	381	110	653	587	473	358	302	663	579
1962	418	522	1055	1089	1100	982	909	737	685	490	479	633	756
1963	931	844	1025	620	399	147	376	356	382	347	343	328	509
1964	115	21	485	772	698	444	655	630	618	430	615	490	497
1965	750	1012	1055	1089	1100	983	1056	754	861	768	695	916	918
1966	968	1100	1055	1024	1042	817	372	645	488	394	382	331	717
1967	271	762	1055	671	566	191	294	477	514	574	612	431	535
1968	133	23	1055	960	1018	833	576	699	825	393	793	570	655
1969	794	1100	1055	1089	1100	717	912	624	677	441	463	751	807
1970	981	1100	1055	1089	1100	983	1035	813	803	596	576	993	925
1971	983	1100	1055	1089	1100	983	807	565	811	495	525	759	854
1972	845	1100	1055	821	804	618	363	448	490	344	343	302	627
1973	582	1100	1055	1089	1100	904	1050	865	871	732	621	629	881
1974	627	1100	1055	887	917	766	767	805	668	441	390	271	723
1975	195	1100	1055	1089	1100	983	887	841	858	729	601	571	832
1976	620	1100	1055	775	722	480	466	536	545	413	343	263	609
1977	177	703	1044	284	0	18	323	436	401	280	332	465	374
1978	199	22	0	1084	1100	17	384	715	824	751	449	577	506
1979	542	1100	1055	1089	1100	983	1039	887	878	743	569	593	880
1980	692	1082	1055	1089	1100	983	1028	681	694	359	257	258	771
1981	162	1100	1055	1089	980	659	483	358	394	362	266	282	597
1982	457	338	367	488	1100	980	669	394	755	535	609	929	631
1983	813	1100	1055	1089	1100	975	1016	736	829	756	744	501	891
Average	568	818	937	884	853	645	702	633	662	490	493	527	683
Std.Dev.	295	395	290	249	337	361	272	161	169	155	163	217	177
Maximum	983	1100	1055	1089	1100	983	1060	887	878	780	877	993	925
Minimum	82	0	0	284	0	0	278	356	382	280	257	198	240

9.3.2 Agricultural Demands

Diversions through the Gunnison Tunnel under Scenario 1 are shown in Table 9.3. These diversions consist of water taken under both the senior irrigation decree and the junior hydropower decree and its recently applied for increase. Diversions average 661,000 af per year compared to the historical average of 335,000 af per year.

Gunnison Tunnel diversions under the senior irrigation decree are supported by storage releases from Blue Mesa pursuant to the terms of the Taylor Park Exchange agreement. If the sum of UVWUA storage credits in Blue Mesa and physical contents of Taylor Park are zero, the senior Tunnel decree has access only to direct flow diversions up to the amount of inflow to Blue Mesa Reservoir. The total amount of UVWUA water held in storage in Blue Mesa and Taylor Park under Scenario 1 is shown in Figure 9.1. As can be seen, there are two occasions in the 32-year study period when UVWUA storage was depleted. This occurred in the late summers of 1957 and 1977. At these times Tunnel diversions under the senior decree were constrained to only the amounts available as direct flow plus any remaining UVWUA storage.

TABLE 9.3

Gunnison Tunnel Diversions
Scenario 1
Values in af

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	64039	52688	69234	69666	62924	69666	67419	69666	67419	69666	69666	67419	799472
1953	69666	67419	69666	57390	48676	52971	44550	64817	64271	65799	69666	60900	735791
1954	61386	61717	61406	25595	8205	3253	43243	60705	59400	61380	61380	50906	558576
1955	29647	2673	1105	21606	2938	3253	42946	60705	59400	61380	61380	51737	398770
1956	31120	2673	15298	27844	38808	37258	42946	60705	62311	61380	69666	51678	501687
1957	35000	18473	15128	46920	62924	69666	67419	69666	67419	69666	69666	67419	659386
1958	69666	67419	69666	69666	62628	69666	67419	69666	67419	69666	69666	53935	806482
1959	61218	59281	69666	42720	23895	13565	43956	61380	59400	61380	69666	50906	617033
1960	29585	25423	59806	45372	18712	37047	57024	60705	65815	69666	69666	56074	594895
1961	60586	58865	60406	40081	17722	8777	42946	60705	59400	61380	69666	50906	591440
1962	29585	21182	60606	46474	62924	69666	67419	60705	67419	69666	69666	64687	689999
1963	69666	52985	66843	39406	21067	11294	43124	61380	59400	61380	69666	50906	607117
1964	30199	2673	15427	26333	15782	20808	42946	66290	62726	61380	69666	51262	465492
1965	63889	60280	59106	69666	62924	69666	67419	69666	67419	69666	69666	67419	796786
1966	69666	67419	69666	63528	52668	56285	43006	69175	60529	61380	69666	52094	735082
1967	29708	39263	61806	42966	29827	15529	46629	60705	59400	61380	69666	50906	567785
1968	33882	2673	14827	24524	35563	49737	49124	60705	67063	69666	69666	60134	537564
1969	63539	61080	60406	63106	62924	50270	64865	65255	67360	69666	69666	62128	760265
1970	69666	67419	69666	69666	62924	69666	67419	69666	67419	69666	69666	67419	820262
1971	69666	67419	69666	69666	62924	69666	67419	69666	67419	69666	69666	67419	820262
1972	69666	67419	69666	52234	41802	44685	43837	61380	59400	61380	69666	50906	692041
1973	39836	59080	59586	69666	62924	58848	54648	67809	67419	69666	69666	67419	746587
1974	62915	65619	69666	56224	47290	54076	47995	69666	64449	65001	69666	50906	723473
1975	34925	61280	61506	62006	62528	63922	67419	69605	67419	69666	69666	67419	757361
1976	56470	65719	69666	49534	37810	34618	43006	61380	59400	61380	69666	51084	659733
1977	30199	38432	58386	18782	998	3253	43065	60705	59400	51000	47000	16600	427820
1978	22900	2673	600	19477	24915	3253	43006	60705	66884	69666	69666	55836	439581
1979	56777	59280	58506	67154	62924	69666	67419	69666	67419	69666	69666	60410	778553
1980	63774	64033	69666	66077	62924	69666	67419	69666	67419	69666	69666	51143	791119
1981	59907	64289	69666	59106	50284	45851	56311	60275	50193	59968	59968	43124	678942
1982	43518	18473	13748	30997	49900	52715	53935	54383	50469	69666	69421	66053	583278
1983	66843	63083	69666	67600	62148	62915	63320	69666	67419	69666	69666	67419	799411
Average	51535	46513	53429	49408	43231	44099	54082	64589	63616	65665	68129	56393	660688
Std.Dev.	16574	23854	23090	17300	20420	24238	10655	4446	4251	4750	4574	10215	124154
Maximum	69666	67419	69666	69666	62924	69666	67419	69666	67419	69666	69666	67419	820262
Minimum	22900	2673	600	18782	998	3253	42946	54383	50193	51000	47000	16600	398770

Despite these minor constraints on Tunnel diversions, there were no shortages to Uncompahgre Project agricultural demands under Scenario 1. Shortages to other agricultural demands evident in Scenario 1 are summarized by sub-basin in Table 9.4. In examining the shortages shown in Table 9.4, it should be remembered that the smaller water rights were represented as aggregated depletions. Therefore, the shortages shown in the table, except for Bostwick Park, are shortages to a depletion demand rather than a diversion demand. Because diversions typically exceed depletions by anywhere from 50 percent to a factor of 4 over the irrigation season, the shortages shown in Table 9.4 understate the actual diversion shortages at individual ditch headgates. It should also be noted that the average annual shortage shown in the table is the average for the years that shortages occurred.

TABLE 9.4

Shortages to Agricultural Demands
Scenario 1
(values in acre-feet)

Sub-basin	# of Years W/Shortage	Max Annual Shortage	Avg Annual Shortage	Monthly Distribution
Ohio Creek	5	1831	793	June and July
Tomichi Creek	6	3145	1413	May through August
Cochetopa Creek	3	721	469	May through July
Blue River	20	920	243	June through September
Cow Creek	3	756	394	April
Bostwick Park	1	420	420	August, September
Upper Spring Creek	32	167	72	July through September
Happy Canyon Creek	32	143	89	July through September
Horsefly Creek	32	118	53	May through September

Under Scenario 1, chronic water shortages were found in the upper reaches of tributaries to the Uncompahgre River (Spring Creek, Happy Canyon Creek, and

Horsefly Creek), and in the Blue River basin. These shortages are relatively small but occur annually, except on the Blue River where they occur two years out of three.

More severe but much less frequent water shortages are found on Ohio, Tomichi, and Cochetopa Creeks, and on Cow Creek. These shortages occur primarily in dry years.

Late-season shortages occurred to the Bostwick Park demand in 1977 because Silver Jack storage was depleted and adequate supplies were not physically available to the Cimarron Canal direct flow decrees. The total amount of the shortage, however, was less than 2 percent of the demand in that year.

9.3.3 Instream Flows

For discussion purposes, failure to meet a decreed instream flow right is termed herein an instream flow deficiency rather than a shortage. Most of the existing instream flow decrees are concentrated in the upper Gunnison basin. Below Blue Mesa the principal reaches of interest are the Black Canyon and the Cimarron River.

In the upper basin, the most significant instream flow deficiencies are on Ohio, Tomichi, and Cochetopa Creeks, although minor deficiencies were noted on many streams. These instream flow deficiencies are summarized in Table 9.5. Some reaches on these creeks are periodically dried up under this model scenario.

On Ohio Creek, the critical reach is along the lowest portion of the Creek where a year-around decree of 12 cfs is in place. Zero flows occurred in this reach during the summer months in five years of the study period. Upstream reaches of Ohio Creek showed no deficiencies.

TABLE 9.5

Upper Gunnison Instream Flow Deficiencies
Scenario 1

Stream	Reach	Decreed Flow Rates cfs[1]	Deficiency
Brush Creek	M&E Brush to W Brush	8(sum), 5(win)	None
	W Brush to Jarvis D	12(sum), 7(win)	None
Castle Creek	N&S Castle to Acme D	7 year around	Winter
Cebolla Creek	E&W Cebolla to Brush Cr	4 year around	None
Cement Creek	Hdwtrs to East River	10 year around	Winter and July
Cimarron River	Fox Cr to L. Cimarron	25(sum), 15(win)	Minor
	L. Cim. to Gunnison R.	16 year around	Minor
Cochetopa Creek	Pauline Cr to Tomichi Cr	8.5 year around	May through July
East River	Copper Cr to Brush Cr	25(sum), 15(win)	None
	Alkali Cr to Taylor R	50(sum), 27(win)	Minor
Lake Fork	Henson Cr to Blue Mesa	45(sum), 25(win)	None
Ohio Creek	Castle Cr to Mill Cr	10 year around	Winter
	Mill Cr to Gunnison R	12 year around	June through Aug.
Quartz Creek	N&M Quartz to Gold Cr	10 year around	Frequent but small
	Gold Cr to Tomichi Cr	12 year around	Fall and winter
Slate River	Coal Cr to East River	23(sum), 12(win)	Aug. through Mar.
Soap Creek	W Soap Cr to Blue Mesa	12(sum), 7(win)	April and May
Taylor River	Illinois Cr to Taylor Res	55 year around	Frequent but small
	Taylor Res to Spring Cr	445 year around	Frequent
	Spring Cr to East River	200(sum), 80(win)	Occasional small
Tomichi Creek	Triano Cr to Marshall Cr	9 year around	Aug. through April
	Marshall Cr to Quartz Cr	18 year around	Frequent severe

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[1] definition of "summer" and "winter" is specific to each decree

On Tomichi Creek, minor deficiencies are found in many months along the entire length of the creek. The critical reach is that immediately upstream of Cochetopa and Quartz Creeks where an instream flow decree for 18 cfs is in place. Zero flows were found in this reach in six years of the 32-year study period and generally occurred in the summer months.

Cochetopa Creek also experiences minor instream flow deficiencies periodically all along its length. The critical reach appears to be just upstream of the confluence with Los Pinos Creek; zero flows are observed in this reach in three of the 32 years of the study period. The reach is decreed for an instream flow of 8.5 cfs.

Instream flows in the Black Canyon for Scenario 1 are shown in Table 9.6. These flows were maintained by Blue Mesa releases when normal operations were insufficient to provide the 300 cfs target flow. The flow target was met throughout the study period, although if Blue Mesa were to stay at minimum power pool for another month in the spring of 1957 the modeled instream flow release would have been curtailed. Table 9.7 shows the additional operational releases made from Blue Mesa Storage to support the Black Canyon instream flow regime.

Direct comparisons of the instream flows in Table 9.6 and those presented in the Draft Environmental Assessment for the AB Lateral Hydropower Project (USBR, 1988) should be made with caution. The hydrologic modeling for these two studies was undertaken with different purposes in mind and the two models differ in many important respects, most notably in geographical scope. Therefore, the resulting flow regimes should not be expected to agree precisely.

9.3.4 Reservoir Contents

Figures 9.2 through 9.5 display the modeled water surface elevations for Taylor Park, Blue Mesa, Silver Jack, and Ridgway Reservoirs under Scenario 1. Taylor Park Reservoir fills or nearly fills in 16 years of the study period as

shown in Figure 9.2. The reservoir never empties in this scenario but does drop below 30,000 af three times.

TABLE 9.6

Black Canyon
Average Monthly Flow (cfs)
Scenario 1

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1952	300	496	300	468	1453	1717	2774	2069	2398	1193	1137	797	1253
1953	464	364	421	649	523	439	665	441	1013	312	300	300	490
1954	300	309	300	999	1274	1252	300	300	313	300	300	300	517
1955	300	471	481	459	445	396	300	300	300	300	300	300	362
1956	300	493	300	300	477	737	300	300	653	300	300	430	406
1957	300	300	300	300	1465	623	1131	2483	4035	3395	2568	1153	1503
1958	602	539	603	700	300	355	794	1540	4499	300	300	449	913
1959	300	400	392	572	984	1230	654	512	816	300	300	452	573
1960	858	926	300	300	300	300	663	300	775	300	300	356	472
1961	300	342	300	743	300	447	300	300	604	300	300	530	398
1962	903	300	300	300	861	1101	1163	300	889	569	565	487	642
1963	411	587	394	621	1044	1216	693	484	359	300	300	472	570
1964	813	565	300	300	300	300	300	503	998	419	300	514	468
1965	300	300	300	451	1028	441	1501	1302	1664	1187	1807	1476	977
1966	891	542	544	414	567	596	870	770	515	310	300	424	561
1967	850	681	300	607	559	610	300	300	567	300	300	499	489
1968	733	1280	300	300	300	300	300	300	1194	300	300	300	491
1969	300	300	300	300	1407	1054	859	300	605	336	300	300	523
1970	925	525	468	1071	802	391	858	1956	2711	1463	1039	2115	1193
1971	1026	680	636	399	514	783	582	806	1150	354	525	761	685
1972	511	488	472	846	1118	744	637	549	707	300	300	454	590
1973	701	300	300	301	343	300	300	300	1454	450	618	454	485
1974	444	300	347	365	885	499	744	1176	761	300	300	447	544
1975	755	300	300	300	300	300	524	668	1289	1666	676	301	618
1976	455	300	358	546	816	746	761	702	704	300	300	500	538
1977	774	653	300	945	606	491	300	300	300	300	300	300	464
1978	300	300	300	300	300	933	403	300	956	587	300	425	451
1979	410	300	300	300	824	870	1231	674	1879	1093	723	488	755
1980	382	319	324	300	978	1046	1773	1623	2289	407	300	514	850
1981	405	300	380	300	526	547	441	351	579	389	369	300	406
1982	300	300	300	593	300	300	554	387	744	587	416	1091	487
1983	989	565	386	300	303	318	432	1014	3499	3889	1822	801	1199
Average	550	463	363	489	694	668	731	737	1288	713	571	578	652
Std.Dev.	251	214	94	227	373	358	518	592	1067	843	536	386	281
Maximum	1026	1280	636	1071	1465	1717	2774	2483	4499	3889	2568	2115	1503
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	362

TABLE 9.7

Blue Mesa Releases for Black Canyon Instream Flow
Scenario 1
Values in AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	5431	0	5431
1954	0	0	0	0	0	0	17820	18414	0	1256	18414	17820	73724
1955	14991	0	0	0	0	0	17820	18414	17708	1588	18414	17820	106755
1956	17628	0	0	0	0	0	17535	18414	0	0	10540	0	64117
1957	17077	2579	0	0	0	0	0	0	0	0	0	0	19656
1958	0	0	0	0	0	0	0	0	0	5305	9261	0	14566
1959	0	0	0	0	0	0	0	0	0	1114	8185	0	9299
1960	0	0	0	0	0	0	0	18414	0	3985	10540	0	32939
1961	0	0	0	0	0	0	17820	7272	0	2509	10085	0	37686
1962	0	0	0	0	0	0	0	2142	0	0	0	0	2142
1963	0	0	0	0	0	0	0	0	0	1797	10187	0	11984
1964	0	0	0	0	0	4017	14179	0	0	0	1914	0	20110
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	9295	0	9295
1967	0	0	0	0	0	0	17820	18414	0	459	9905	0	46598
1968	0	0	0	0	0	0	17820	9455	0	3129	1089	0	31493
1969	0	0	0	0	0	0	0	0	0	0	6725	0	6725
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	2129	10495	0	12624
1973	0	0	0	0	0	0	4112	0	0	0	0	0	4112
1974	0	0	0	0	0	0	0	0	0	4145	9850	0	13995
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	1814	10260	0	12074
1977	0	0	0	0	0	0	17820	17530	0	0	11136	11994	58480
1978	18414	17464	4137	0	0	0	0	18414	0	0	4129	0	62558
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	9830	0	9830
1981	0	0	0	0	0	0	0	0	0	0	0	17820	17820
1982	18414	3125	0	0	0	0	0	0	0	0	0	0	21539
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	2704	724	129	0	0	126	4461	4590	553	913	5803	2045	22049
Std.Dev.	6303	3085	720	0	0	699	7487	7530	3081	1449	5577	5485	25729
Maximum	18414	17464	4137	0	0	4017	17820	18414	17708	5305	18414	17820	106755
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0

Blue Mesa Reservoir levels are displayed in Figure 9.3. The reservoir is never drawn down to the minimum power pool over the 32-year study period. Blue Mesa fills or nearly fills in 12 of the 32 years of the study period.

Silver Jack Reservoir levels are displayed in Figure 9.4. The reservoir fills in all but three of the 32 years modeled in the scenario. The Silver Jack Reservoir active pool is emptied in 1957 and 1978.

Ridgway Reservoir levels are displayed in Figure 9.5. The reservoir fills or nearly fills in 19 years of the 32 year study period. The reservoir is drawn down to the inactive pool twice, in 1975 and in 1978.

9.4 Summary

Scenario 1 showed that shortages to some irrigation demands will occur in upper Gunnison and Uncompahgre basins under future demand conditions. In the upper Gunnison, the most severe irrigation shortages were noted on Ohio Creek, Tomichi Creek, and Cochetopa Creeks. Other less severe but more chronic irrigation shortages were found on the Blue River.

In the Uncompahgre basin the most severe shortages were noted on Cow Creek, Chronic shortages occurred on upper reaches of the smaller tributaries of the Uncompahgre near Montrose, namely Horsefly, Happy Canyon, and Spring Creeks.

Scenario 1 showed widespread instream flow deficiencies in the upper Gunnison. Nearly all streams having instream flow decrees show periods when those decrees are not met. The most severe instream flow deficiencies are on Ohio, Tomichi, and Cochetopa Creeks. In some years these streams are dried up completely. Increased irrigation efficiencies will not necessarily result in greater streamflows in some of these critical reaches as any increase in return flows might be taken under other irrigation rights. Other possibilities for increasing these flows would be to buy out irrigation decrees or to provide upstream storage.

Scenario 1 showed that maintenance of the 300 cfs minimum streamflow in the Black Canyon can be achieved over the entire study period. This instream flow maintenance requires annual average operational releases from Blue Mesa of 22,000 af.

Under the conditions depicted in Scenario 1, the operational cycles for basin reservoirs are more regular and somewhat more pronounced than historical or contemplated operations. However, the principal reservoirs operate at nearly the same levels or at higher levels than historically occurred or was anticipated in pre-project operations studies.

FIGURE 9.1

TAYLOR PARK EXCHANGE ACCOUNT STATUS
Scenario 1

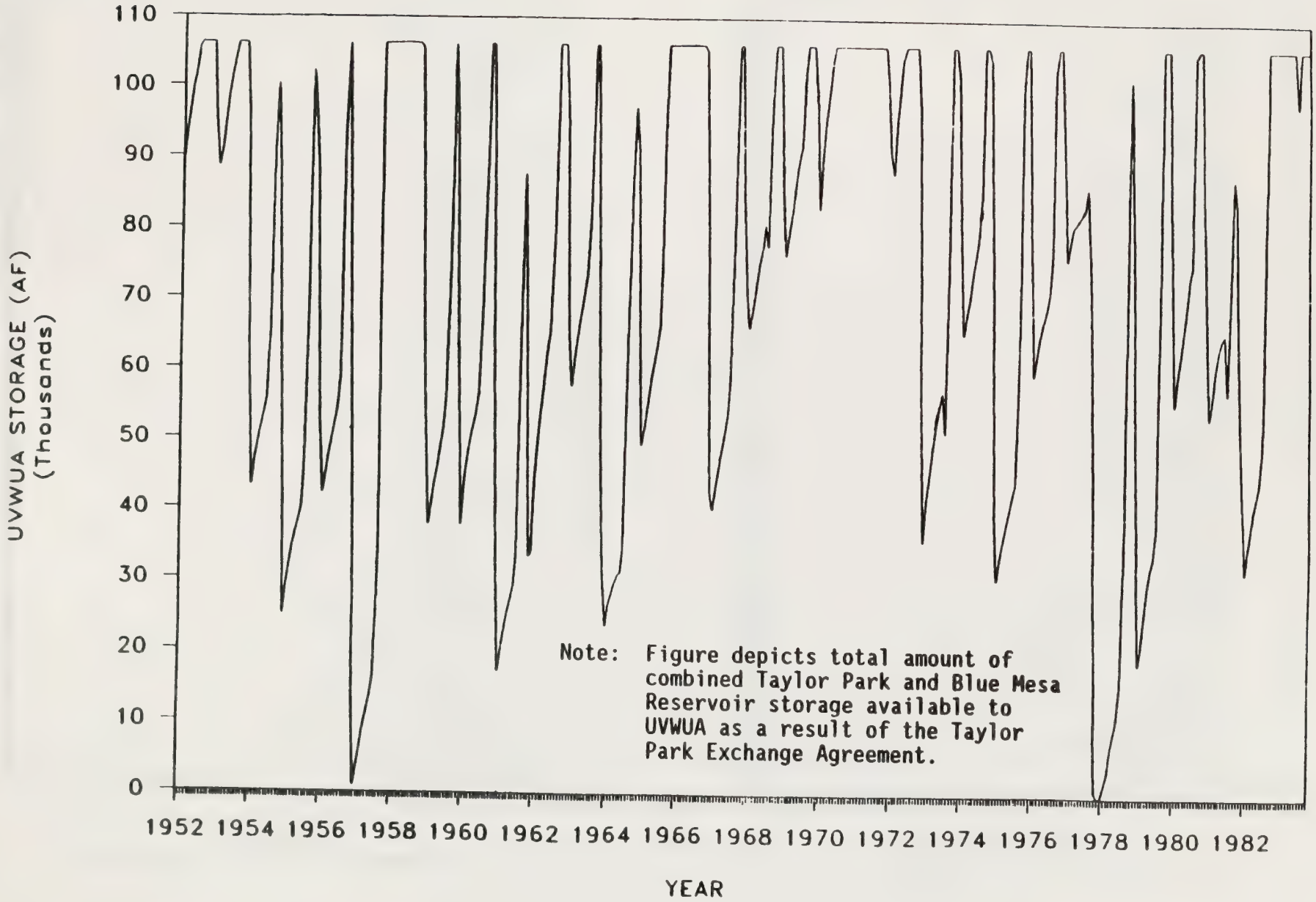


FIGURE 9.2

TAYLOR PARK RESERVOIR LEVEL
Scenario 1

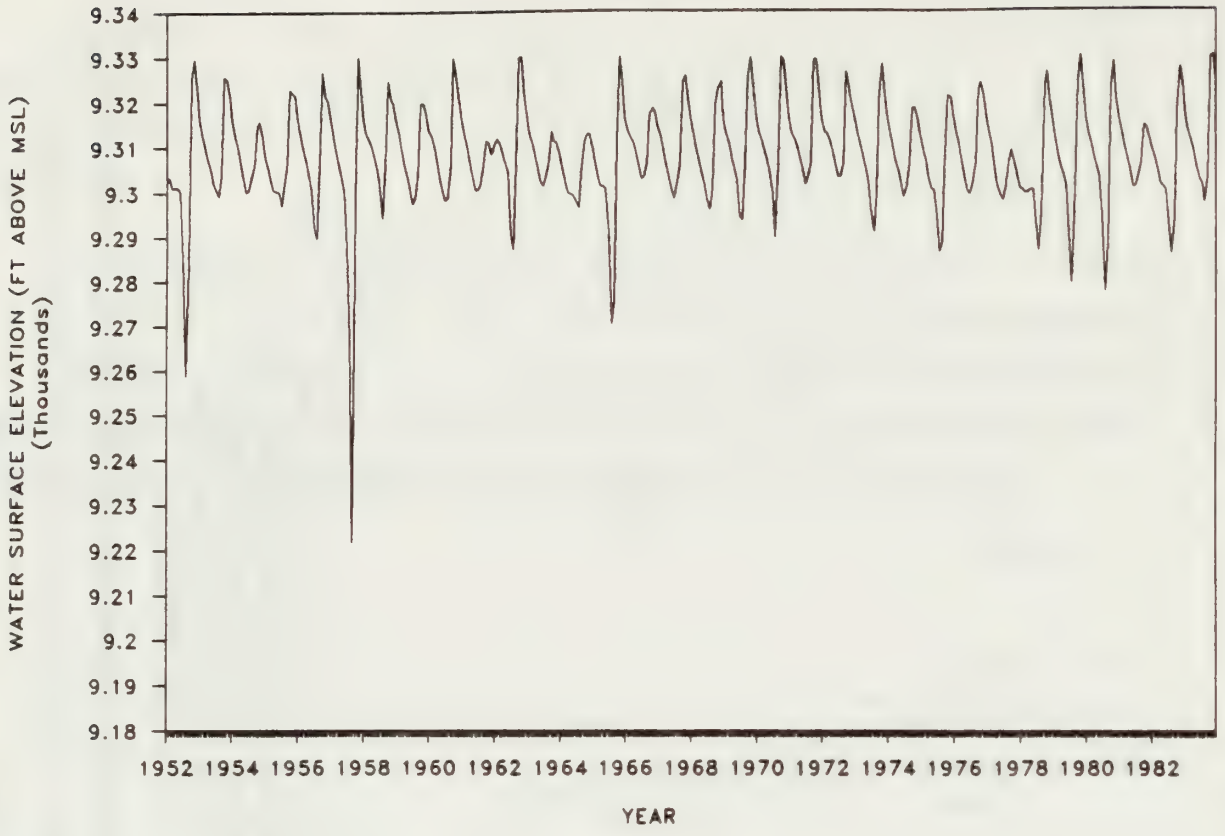


FIGURE 9.3

BLUE MESA RESERVOIR LEVEL
Scenario 1

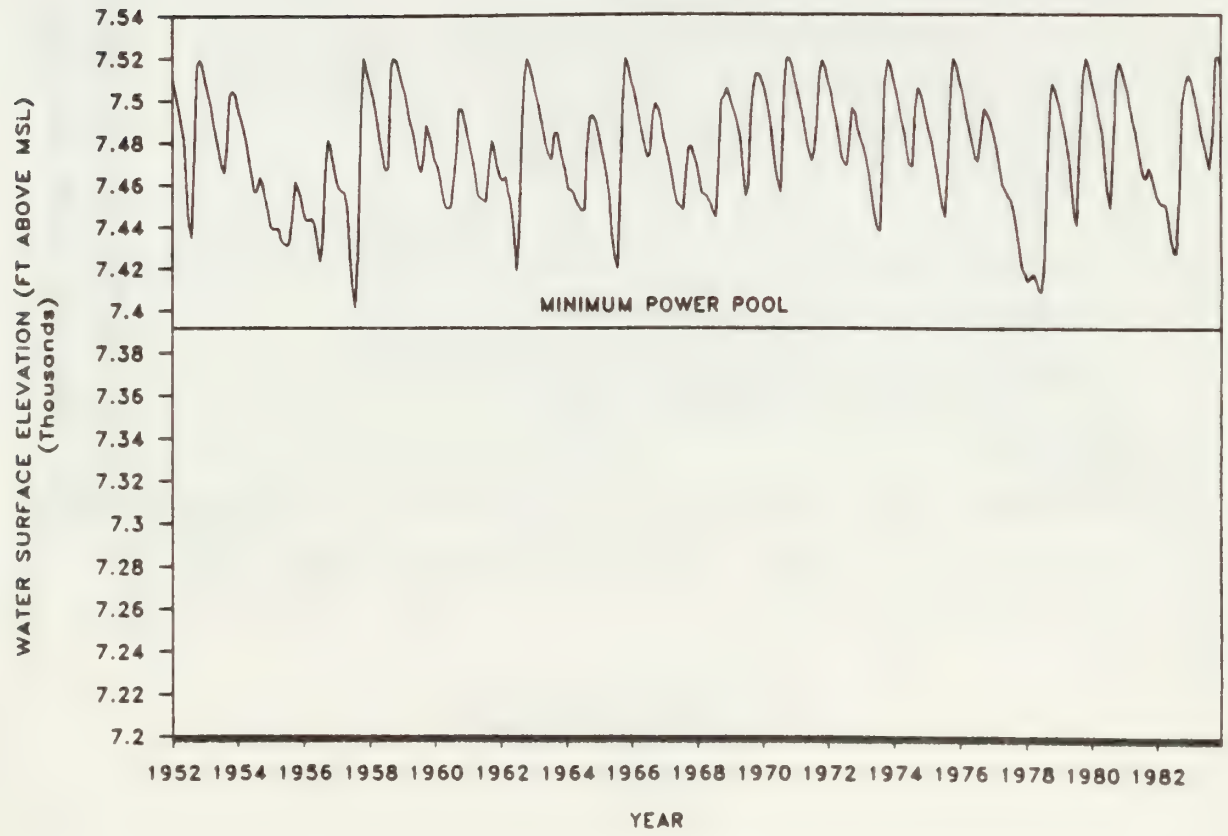


FIGURE 9.4

SILVER JACK RESERVOIR LEVEL
Scenario 1

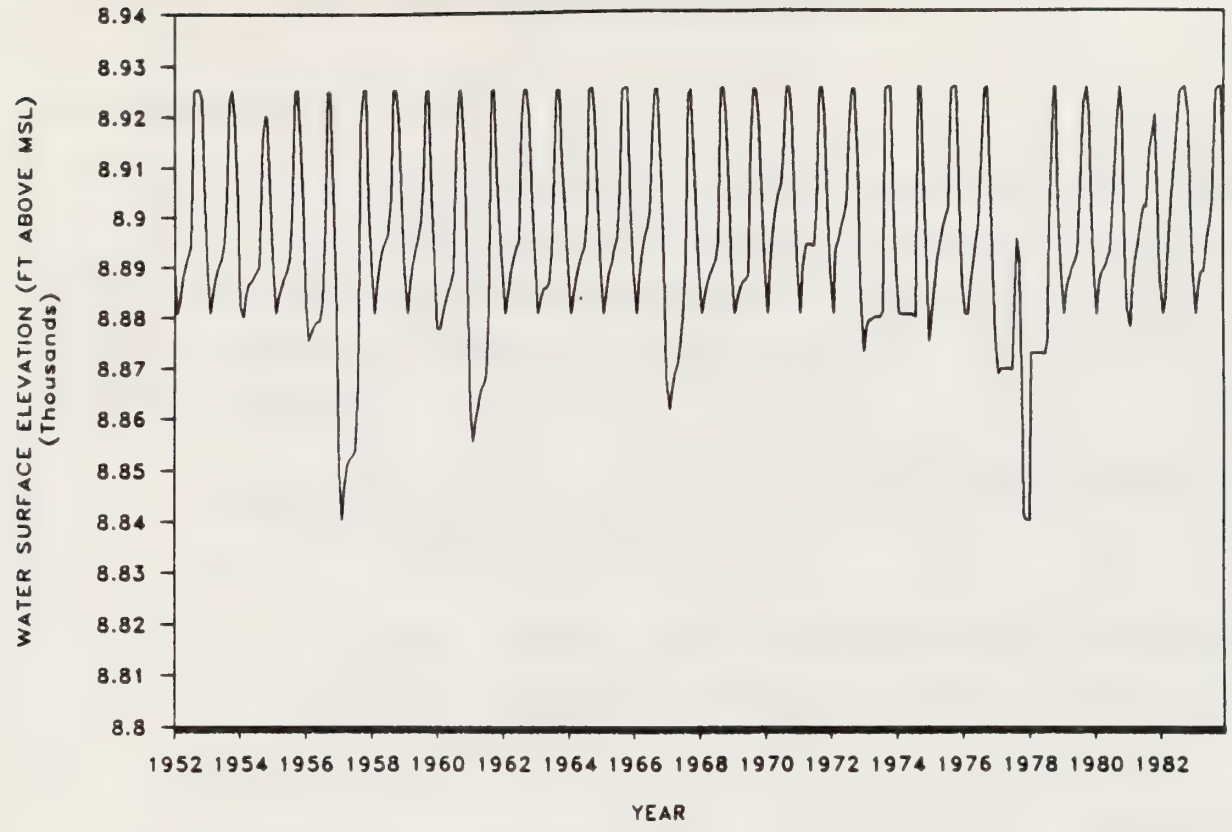
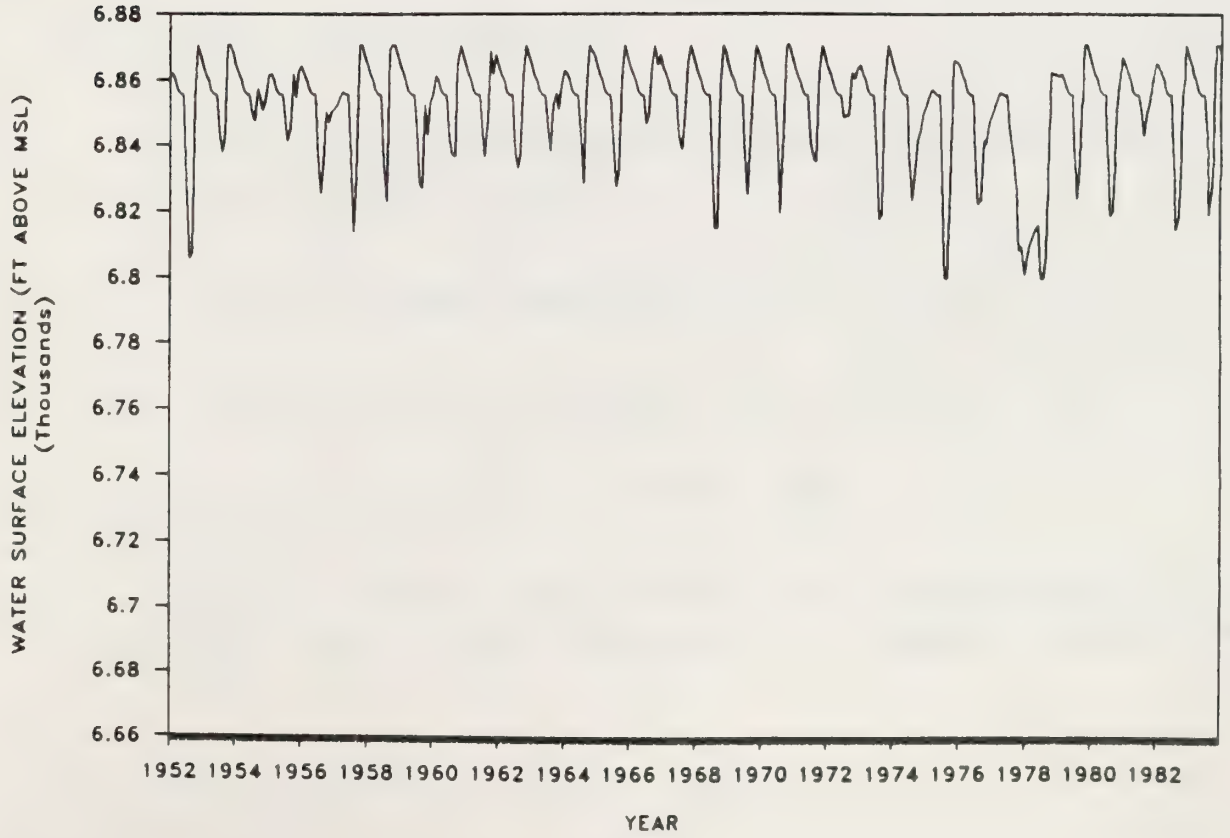


FIGURE 9.5

RIDGWAY RESERVOIR LEVEL
Scenario 1



10.0 WATER MANAGEMENT AND CONSERVATION MEASURES

10.1 INTRODUCTION

Water management and conservation measures are non-structural components which do not utilize major physical structures or facilities to achieve their purpose. Generally, they can be implemented at low cost in comparison to structural components, especially storage reservoirs. These components are defined as follows:

- Conservation measures which result in an increased availability of water or a reduction in water demand.

- Water management measures which improve the way in which water is utilized and/or allocated, resulting in demands being met without the need to construct physical facilities.

This chapter discusses the identification, evaluation and screening of conservation and water management components which may be considered as components of alternative plans.

10.2 IDENTIFICATION OF COMPONENTS

Conservation and water management components were identified by review of the following published sources:

- St. Vrain Basin Reconnaissance Study (R.W. Beck, 1986)

- Cache La Poudre Basin Study (Harza, 1987)

- Draft Denver Metro SEIS (USCOE, 1986)

A review of existing water supplies, water use practices and water users in the study area was also undertaken in an attempt to identify components

that had not been previously identified in published sources; however, none were identified.

A list of the conservation and water management components identified and evaluated in this study is presented in Table 10.1.

TABLE 10.1

Water Conservation and Management Components

Water Conservation Components:

- Phreatophyte Control
- Ditch Lining and On-Farm Efficiency Improvements
- Evaporation Suppression
- Municipal and Industrial Water Conservation

Water Management Components:

- Water Rights Exchange Agreements
- Drought Insurance
- Conjunctive Use of Ground and Surface Water

Since irrigated agriculture accounts for the majority of the water use in the Study Area, and since agricultural land in the Upper Gunnison area can be purchased at reasonable prices at present, it would appear that purchasing land and taking it out of production may be an economical means of increasing streamflow for fish, wildlife, and recreation purposes. One of the objectives of the present study, however, is to meet future agricultural water demands and therefore the possibility of taking land out of production was not considered in this study.

10.3 WATER CONSERVATION COMPONENTS

10.3.1 Phreatophyte Control

There are approximately 12,000 acres of phreatophyte growth consisting of willows or cottonwoods in hay meadows and along natural drainages and unlined irrigation systems in the study area. About 4000 acres is within the Upper Gunnison sub-basin with the remainder in the Uncompahgre sub-basin. Applying an average annual consumptive use rate of 1.65 ft per acre results in a total annual consumptive use of 19,800 af associated with these lands. Conceivably, a portion of this consumptive use could be eliminated if phreatophyte control measures were implemented. However, the lands containing phreatophytes have significant aesthetic value, provide valuable wildlife habitat, stabilize stream and canal banks, and provide some measure of water temperature reduction in streams as a result of the shade provided by the phreatophytes. In addition, there is the question of who would bear the initial expense of clearing the growth and the annual maintenance cost to maintain the cleared condition versus who would benefit from these actions. It is estimated that the cost of effectively clearing phreatophyte growth the first time is in the order of $250 per acre. Under present water rights law, there is no mechanism to compensate a water right holder for the water saved by his efforts to control phreatophyte growth.

10.3.2 Ditch Lining and On-Farm Efficiency Improvements

In determining irrigation water requirements, off-farm conveyance system losses (losses occurring between the point of diversion from a natural stream or river and the farm headgate) ranging from 40 to 50 percent were applied to farm headgate requirements to determine diversion estimates for individual ditch systems. It was estimated that by lining irrigation ditches or replacing them with pipe distribution systems, potential annual water savings of approximately 7500 af would be realized under the moderate growth scenario. Incremental annual costs associated with lining unlined irrigation systems is estimated at $22 per acre. Considering that the total irrigated area is

approximately 170,000 acres, this results in an annual unit cost of about $500 per af.

On-farm efficiency and water savings could be achieved by land leveling in the Upper Gunnison area and conversion from flood irrigation to sprinkler irrigation practices throughout the study area. The possibility of implementing land leveling is remote because the soils are relatively thin and the cost would be objectionable to landowners under present economic conditions. Also, several of the landowners have expressed an opinion that land leveling will result in significant growth of noxious weeds in their fields after the leveling is complete (personal interviews with local ranchers).

Regarding conversion to sprinkler irrigation, the present and foreseeable future market value of the crops under cultivation in the study area would not warrant the high cost involved (estimated capital and annual costs are approximately $1200 per acre and $140 per acre per year, respectively).

10.3.3 Evaporation Suppression

It is estimated that a total of approximately 15,000 af of net evaporation takes place annually from the six major reservoirs (Federal facilities) located within the study area. Previously studied or proposed methods of evaporation suppression include: windbreaks; floating reservoir covers; and application of monomolecular films or other agents to the water surface. These measures are not considered technically feasible for large reservoirs and the cost would be prohibitive.

10.3.4 Municipal and Industrial Water Conservation

For the purpose of this study, a number of water saving measures related to municipal and industrial supply were grouped in this category. The specific measures included in this component are as follows:

Reuse of Municipal Waste Water	Public Awareness Program
Reduce System Leakage	Increasing Block Rate System
Low Demand Fixtures	Universal Metering
Outdoor Watering Restrictions	Water Use Rationing
Landscape Restrictions	Commercial/Industrial Conservation

It is estimated that municipal and industrial consumptive water use in the study area is 1.35 percent of the total consumptive use. That figure is expected to increase in the future to somewhere between 2.0 and 5.0 percent. Although these measures are worthy of consideration at the local level, the potential savings as a result of implementation will result in an extremely small reduction in the total consumptive use in the study area. Legislation introduced in the 1989 Colorado General Assembly would encourage greater water conservation and underscores the need for local conservation programs.

10.4 WATER MANAGEMENT COMPONENTS

10.4.1 Water Rights Purchases and Exchanges

There is water available in certain existing reservoirs located in the study area which could be purchased to meet downstream needs and/or exchanged to an upstream location to meet needs in the upper basin or to support transmountain diversions. These possibilities are discussed below.

10.4.1.1 Water Available for Purchase/Lease

Blue Mesa Reservoir. It is estimated that up to 180,000 af of uncommitted firm annual yield is available from Blue Mesa reservoir storage (USBR estimate) in addition to the 60,000 af of storage which has

been subordinated to junior in-basin depletions. Indications are that the U.S. Department of Interior (USDI) would be willing to sell that uncommitted water under a long-term contract arrangement. The purchase price of water from Blue Mesa for municipal purposes is estimated by the USBR to be approximately $50.00 per af at present (1988). Implementation of any purchase agreement for water from Blue Mesa Reservoir would be subject to the terms of the assignment of the Blue Mesa Reservoir storage and direct flow water rights from the Colorado River Water Conservation District (CRWCD) to the United States. Use of Blue Mesa water in export projects is conditioned upon prior consent of parties to that agreement. There may also be other legal or institutional constraints regarding purchases of Blue Mesa water; this study has not analyzed such constraints.

Ridgway Reservoir. It is estimated that approximately 14,000 af of the 28,100 af of M&I firm yield from Ridgway Reservoir storage is committed to the City of Montrose and the Towns of Delta and Olathe. Tri-County Water Conservancy District has indicated a desire to retain approximately 4000 af of the remaining yield to meet unforeseen future needs. It appears therefore that approximately 10,000 af could be made available for short-term lease to other entities. The purchase price of water from Ridgway Reservoir is $300 per af at present (1989).

10.4.1.2 Potential Exchange and Transfer Scenarios

Blue Mesa - Taylor Park Exchange. The 180,000 af of water available for purchase from Blue Mesa might be used to effect an exchange which would allow water to be diverted from Taylor Park Reservoir to the east slope. Taylor Park Reservoir is located in the upper reaches of the Taylor River approximately 8 miles west of the continental divide with a normal water surface elevation of 9330 ft and active storage capacity of 106,000 af. Water can be delivered to the Arkansas and/or the South Platte River basins from Taylor Park Reservoir. Under this concept, the diverting entity would execute a contract with the USBR for the long-term purchase

of firm annual yield from Blue Mesa Reservoir. This entity would simultaneously execute an exchange agreement with the UVWUA and the USBR. Under this agreement, releases would be made from Blue Mesa to supply the irrigation needs of the UVWUA in exchange for a transbasin diversion from Taylor Park Reservoir. As discussed in the preceding section, implementation of such a purchase/exchange agreement would be institutionally complex and would have environmental impacts which would require careful study and mitigation. Also, since Blue Mesa water is junior to the UVWUA water right involved, UVWUA would require adequate protection or compensation for their participation in such an agreement.

Ridgway - Taylor Park Exchange. The 10,000 af of firm yield apparently available from Ridgway Reservoir might be used in a transmountain diversion project in much the same way as described above. Under this concept, the diverting entity would execute a contract with Tri-County Water Conservancy District for the lease of firm annual yield from Ridgway Reservoir. This entity would simultaneously execute an exchange agreement for this yield with the UVWUA. Under this agreement, releases would be made from Ridgway to supply the water needs of the UVWUA in exchange for a direct transbasin diversion from Taylor Park Reservoir.

Transfer of Storage Right. A number of conditional storage decrees exist in the Upper Gunnison Basin including those held by the Upper Gunnison River Water Conservancy District (UGRWCD) and the City of Gunnison. These decrees could be used in an exchange whereby a reservoir constructed in the Upper Gunnison Basin could be used to provide replacement storage for water diverted from Taylor Park Reservoir. These decrees could also be used to support a second filling of Taylor Park Reservoir to accommodate a transmountain diversion from that reservoir.

The exchanges and transfers described above assume that Taylor Park Reservoir is the upper basin diversion point. The exchanges could be utilized with any upper basin diversion point, but Taylor Park Reservoir was used in

the examples because it is an existing reservoir and therefore would not require construction of a new facility to store the exchanged water.

10.4.2 Drought Insurance

Drought insurance refers to a concept whereby an entity would contract with the owner of an agricultural water right to utilize that agricultural water right for other purposes during drought years in exchange for payments to the owner equal to the cost of foregone production plus reasonable profit.

Since the Scenario 1 modeling results discussed in Chapter 9 showed no shortages of M&I water in the study area during the study planning horizon, drought insurance does not appear to be a potential measure to meet in-basin M&I demands. Drought insurance would be a potential method of providing enhanced instream flows for fishery and/or recreation purposes, however.

This concept may also be applicable to a transbasin diversion alternative wherein an entity would contract with a water right owner to have access to the consumptive use portion of agricultural water during drought years. Access to water with sufficient seniority during infrequent low flow periods could significantly enhance the firm annual yield of a transbasin diversion project. The impact of such an arrangement on instream flows, however, could possibly be damaging to the fishery during drought years and would have to be evaluated on a case-by-case basis.

10.4.3 Conjunctive Use of Ground and Surface Water

Conjunctive use of surface and ground water in a basin generally involves using an aquifer as a long-term facility to supplement fluctuating surface water supplies in much the same way as a surface reservoir is operated. The primary requirements for a conjunctive use management program are the existence of aquifers of sufficient capacity and quality, available recharge water, and a means to withdraw and replenish water from aquifer storage.

In this study area, there currently are no identified aquifers with significant storage volume that could be used in a conjunctive use program without seriously degrading water quality with dissolved mineral salts. However, the USBR in association with a private entity has participated in conducting a Proof of Concept study of potential high mountain aquifers occurring behind alpine glacial moraines. The results of the study were inconclusive and the planned follow-on studies have not been initiated to date.

10.5 SCREENING OF COMPONENTS

The screening of non-structural components in the water management and conservation category is based on the target objectives associated with them and consists of a one-step elimination process as shown on Table 10.2. Components which survived the screening were considered in the plan formulation process.

The target objective for water conservation components is:

> Reduce present water consumption in the Study Area by a significant amount, more than ten percent in aggregate (smaller savings, although worthwhile, are not considered appropriate for a basin-wide study to address, but should be treated on an individual basis at the local level).

The target objective for water management components is:

> Meet present or projected water demands to a significant degree by using proven methods to eliminate or defer the need to construct new physical facilities.

The results of the screening process are presented in Table 10.3.

TABLE 10.2

Screening Criteria for Water Supply/Demand Management
Non-Structural Components

Non-structural plan components will be eliminated from further consideration if:

- Major adverse environmental impacts are expected as a result of implementation.
- Minimal reductions in consumptive use are expected as a result of implementation.
- Reductions in water consumption or increases in water availability are small in relation to the cost of implementation.
- Significant institutional/social resistance is expected to implementation.

TABLE 10.3

Summary of Screening Results
Water Management and Conservation Measures

Component	Screening Results	Remarks
Phreatophyte Control	Eliminated	Adverse Environmental impact and high cost.
Ditch Lining	Eliminated	High cost relative to benefit.
On-farm Efficiency Improvements	Eliminated	High cost relative to benefit.
Reservoir Evaporation Suppression	Eliminated	Technically and financially not feasible.
M&I Water Conservation	Eliminated	Insignificant potential savings.
Water Rights Purchase, Exchange and Transfer	Retained	Potential benefit for instream flows and transmountain diversions.
Drought Insurance	Retained	Potential benefit for instream flows and transmountain diversions.
Conjunctive Use of Ground and Surface Water Supplies	Eliminated	Technically not feasible.

11.0 RECREATION IMPROVEMENT COMPONENTS

This chapter presents a broad range of potential recreation improvement opportunities that fall into four categories: fisheries, waterfowl, water-based recreation, and public access. The identification, evaluation, and ranking of the opportunities to arrive at a list of recreation components for consideration in formulating alternative plans is discussed.

11.1 METHODOLOGY

Improvement opportunities were initially identified based upon extensive input provided by area fisheries and recreation experts. At the outset of the study, experts including fishery biologists and resource managers from state and Federal resource management agencies, local government staffs, academic researchers, private resort operators, and knowledgeable local fishermen were requested through interviews, questionnaires, and group meetings to describe and select potential fishery and recreation improvements. This process was intended to provide the study with information tempered by experience and judgement that would be hard to develop from numerical data alone, given the 5100-square mile size of the study area and the level of study.

More than 50 waterbodies that would benefit from improvement were identified in questionnaires during the interviews and during a workshop which was conducted in Gunnison by the study team on July 24, 1987. At the conclusion of the workshop, the participants were asked to make recommendations regarding which stream and reservoir systems should be given priority for improvement. The discussion at the workshop resulted in the development of a list of ten waterbodies and suggested improvements to be studied. After evaluating the input obtained from this group, the Study Team accepted the recommended top priority waterbodies and added one additional stream, Ohio Creek. The following is the selected list of stream and reservoir systems (list arranged geographically starting in the Upper Gunnison sub-basin and proceeding clockwise around the study area) that were evaluated during the study:

- o Gunnison River - Almont to Blue Mesa Reservoir
- o Ohio Creek
- o East River and Slate River
- o Taylor River - Taylor Park Dam to Almont
- o Taylor Park Reservoir and tributaries, Upper Taylor River, Willow Creek, and Texas Creek
- o Tomichi Creek and tributaries, Quartz Creek and Marshall Creek
- o Cochetopa Creek and tributaries, Archuleta Creek and Los Pinos Creek
- o Cebolla Creek
- o Lake Fork of the Gunnison River
- o Blue Mesa Reservoir Tributaries
- o Uncompahgre River below Ridgway Reservoir and tributary, Cow Creek

Once this list of selected areas for fishery and recreation enhancement was developed, a data collection program was undertaken to confirm the conditions and limiting factors described by the area experts, and to establish a basis for further screening of the potential improvement opportunities. The data collected and reviewed includes data assembled from previous studies and data gathered during field surveys conducted by the Study Team in the fall of 1987. The information was used to prepare characterizations of fish habitat, water quality, waterfowl areas, recreation facilities, and existing public access for each of the potential improvement areas. Finally, the recreation opportunities were screened and ranked to arrive at a list of recommended components for inclusion in alternative water resource development plans.

11.2 FISHERY IMPROVEMENT OPPORTUNITIES

Fishery improvement opportunities are discussed for each of the major selected stream and reservoir systems below. Prior to actual project design however, detailed monitoring of each site, the tributary systems to the site, and the area below the site for an appropriate distance must be conducted to confirm the existence of the postulated limiting factors and to ensure the

success of the proposed fishery improvement. The opportunities are not presented in any order of priority.

11.2.1 Gunnison River - Almont to Confluence with Tomichi Creek

1. Provide additional spawning gravels and pool habitat for trout. Placement of large boulders (size = 2.5 to 5 cu yds) in appropriate locations throughout this section would create areas for spawning gravels to accumulate. Boulders should be placed individually or in groups on the inside of meanders 1/4 to 1/2 the channel width from the shore. Because of the scale of equipment and resulting cost for this type of project, any plan should consider boulder placement for a minimum of 4 miles of river during each project with approximately 80 boulders per mile.

2. Improve diversion structures and restore channelized stream sections. Channel stability in the Gunnison River would be improved by decreasing the amount of diversion maintenance that presently takes place annually. Permanent diversion structures and consolidated systems to reduce the number of diversion points would reduce the amount of diversion maintenance needed. Diversions should be placed in the proper flow and stream energy regimes to reduce the level of silt accumulation (and irrigation system maintenance). Ditches should have fish screens to avoid fish stranding. Streambanks should be stabilized to the extent possible with boulders and living shrubs and trees.

3. Provide spawning habitat for rainbow trout during high spring flows in support of the CDOW's plan to develop a wild rainbow trout fishery in this reach. Development of side channels may be able to provide spawning and rearing habitat for rainbow trout during periods of high spring flow. These areas can also provide over-winter and/or escape cover for fry and juvenile fish. These

channels could be incorporated into new irrigation diversion systems that would not need annual "in-the-stream" maintenance.

4. Restore streambank vegetation in order to stabilize streambanks, improve fish cover and food sources.

5. Manage instream flows for development of a wild rainbow trout fishery. The Colorado Division of Wildlife (CDOW) is currently conducting detailed studies (IFG-4 habitat simulations) of the streamflows needed to establish a naturally reproducing wild rainbow trout fishery on the Gunnison River below Almont.

11.2.2 Ohio Creek

1. Reestablish streambank vegetation. Revegetation, fencing, and creating corridors for cattle would improve the condition of streambanks.

2. Develop instream structure and spawning gravels. Installation of pooling devices such as logs, boulders, or log and rock combinations can improve each type of habitat.

3. Restore channelized stream segments.

4. Reduce nutrification of Ohio Creek waters by decreasing septic intrusion.

5. Stock hatchery trout to maintain fish population and the catch per manhour.

6. Reduce spring flood flows to control annual "blow-out" of trout fry and spawning gravels and to produce more favorable conditions for rainbow trout.

7. Increase summer instream flows to maintain suitable trout habitat and water quality.

11.2.3 East River and Slate River

1. Restore streambank vegetation to decrease the bank erosion and sedimentation.

2. Develop additional public access on the East River to reduce heavy fishing pressure on areas that are currently open.

3. Develop pool habitat on sections of the East River and Slate River by installing pooling structures made of wood, rock, and wood/rock combinations. Prior to pool development, streamside vegetation should be restored to ensure that bank and channel sources of sedimentation would be reduced.

4. Institute a range of special fishing regulations to suit angler preferences on designated stream segments.

5. Stock hatchery trout to maintain catch per manhour on headwaters segments.

6. Reduce spring flood flows to control washout of spawning gravels and to produce more favorable conditions for spring spawning rainbow trout.

11.2.4 Taylor River - Taylor Park Dam to Almont

1. Increase water temperature in the Taylor River below Taylor Park Dam. A multi-level outlet system on Taylor Park Dam could provide discharges of water from warmer water layers in Taylor Park Reservoir.

2. Place cobble-size material in streambed to provide riffle habitat for macroinvertebrate insect production.

3. Manage instream flows to protect brown trout spawning areas from mid-October through April.

4. Stabilize streambanks with downed trees or other appropriate measures.

5. Improve brown trout fishery below the confluence with Lottis Creek with special regulations.

6. Stock hatchery trout to increase the catch per manhour in put-and-take reaches.

11.2.5 Taylor Park Reservoir

1. Increase shallow water areas around reservoir by raising dam and flooding flatter meadow areas above current high water level.

2. Control Mysis shrimp in reservoir. At present, no generally accepted or tested methods for controlling Mysis in large cold water reservoirs exist however, it is presently under study by the CDOW (Nesler, 1986).

11.2.6 Upper Taylor River, Texas Creek, and Willow Creek

1. Install pooling structures to increase trout habitat and to slow the flow of water.

2. Establish stream segments with special fishing regulations.

3. Stock hatchery trout to maintain catch per manhour.

11.2.7 Tomichi Creek, Marshall Creek, Quartz Creek, and Cochetopa Creek

1. Restore streambank vegetation and restore channelized stream sections.

2. Improve pool habitat in shallow sections of Tomichi Creek below Sargents and in Cochetopa Canyon by means of installing log structures and boulders.

3. Improve riffle habitat by cleaning sediment off of stream bottom. Install boulder and log placements to create localized flow constrictions that will create clean swept areas.

4. Reduce nutrient loading in Tomichi Creek by controlling irrigation return flows or through dilution by increasing late summer instream flows.

5. Stock fish to maintain catch per manhour on public lands in Upper Quartz Creek, Upper Tomichi Creek, and in Cochetopa Canyon.

11.2.8 Cebolla Creek

1. Restore streambank vegetation.

2. Restore channelized stream segments and install pooling structures.

3. Maintain a reasonable catch per manhour by stocking hatchery trout on sections open to the public. The habitat improvement opportunities described above should be undertaken before more hatchery planting is implemented.

11.2.9 Lake Fork of the Gunnison River

1. Develop additional public access on the Lake Fork.

2. Institute a range of special fishing regulations to suit angler preferences on designated stream segments

3. Stock hatchery trout in designated sections to maintain catch per manhour.

4. Improve instream structure by installing pooling devices such as large 2.5 to 5 cu yd boulders.

11.2.10 Blue Mesa Reservoir and Tributaries

1. Introduce a strain of naturally reproducing wild rainbow trout which are genetically predisposed to grow to large trophy size in a reservoir environment. Included among such varieties are the Kamloops rainbow trout (Gerrard stock) which reach a large size (10 to 30 lbs) and have a long life span (7-10 years versus 3-4 years for hatchery rainbow).

2. Improve pool habitat on tributaries with log weirs and boulders.

3. Restore streambank vegetation and stabilize streambanks on tributaries to control sedimentation of spawning areas for Blue Mesa Reservoir rainbow trout.

4. Eliminate fish passage barriers where tributaries pass through culverts under U.S. Highway 50.

5. Improve shallow warm water areas (littoral zone) around margins of Blue Mesa Reservoir to provide habitat and food supply for trout which will aid growth of larger trout by management of reservoir levels or by construction of dikes to maintain shallow areas as the reservoir level drops.

11.2.11 Uncompahgre River below Ridgway Dam

1. Restore streambank vegetation and stabilize streambanks on Uncompahgre River and on Cow Creek.

2. Restore channelized stream segments.

3. Use special regulations to protect developing fishery.

Until the CDOW completes its recently initiated studies of the developing fishery below the newly completed Ridgway Reservoir, insufficient information exists to confirm specific improvement opportunities. Nevertheless, due to the lack of easily accessible quality trout fishing in the Uncompahgre Valley, when improvement opportunities are identified, they should be given high priority. River segments with potential for becoming good fisheries include the 15-mile segment between Ridgway Dam and the M&D canal diversion and (if the proposed AB Lateral Hydroelectric Project is constructed) the 12-mile segment between Montrose and Olathe.

11.2.12 Targets for Angler Use of Streams after Improvement

Because there are many complex physical and biological factors which interact to produce the conditions necessary for a healthy trout fishery, detailed scientific studies would be needed before any reliable attempt can be made to predict the increase in fish productivity that may result from any single or group of fishery improvements. Nevertheless, preliminary targets for fish production and angler use were developed for the selected study area streams should they undergo improvement. The targets are not predictions for the outcome from any particular improvement or group of improvements, but instead reflect productivity goals that appear to be achievable should an overall improvement of a fishery be undertaken.

The estimates of trout biomass are based on spot electro-shocking surveys, estimates of fish populations that should be supportable by the

stream reaches, consideration of limiting factors, and consideration of possible hatchery stocking rates. The estimates are average figures for large areas of streams.

Targets for angler hours and angler days were based upon the biomass targets using current CDOW fishing statistics. Annual harvest of the wild and stocked biomass present at the beginning of the season was assumed to be 20 percent (roughly the average of the exploitation rate for wild brown trout which is approximately 10 percent in southwest Colorado, and the return to creel rate for stocked rainbow trout which was approximately 30 percent on the Taylor River in 1981-1982).

The weight of the average fish caught was assumed to be 0.3 lbs. The catch per manhour (CPMH) was established at 0.7 fish per hour which is known to produce reasonable angler satisfaction and is a common rate for the study area. A CPMH of 0.35 was used, however, to set targets for angler hours for catch and release brown trout fisheries, because brown trout require a great deal of effort and expertise to catch a second or third time. One angler day is assumed to be accumulated after three hours of fishing.

Targets for angler hours using special regulations have been recommended for several streams. On the Gunnison, Lake Fork, and Uncompahgre Rivers, where it is possible that wild rainbow trout fisheries might develop as a result of the use of special regulations, it is assumed that each fish could be caught an average of five times per year. On streams with predominantly a brown trout population, it is assumed that each fish caught will be caught only an average of two times per year due to the difficulty of recapturing brown trout.

The targets for angler use of streams after improvement are presented in Table 11.1

TABLE 11.1

Targets for Angler Use of Streams after Improvement

			Maximum Lbs Trout Previously Electro-Shocked at any one Station (lbs/acre)	Post-Improvement Targets for Trout Biomass, Wild and Stocked (lbs/acre)	Stream Width (ft)	Angler Hours* AH/acre/Yr)	Anglers Days Per Stream Mile (AD/mi/yr)
1.	Gunnison River	Below Almont	56L, 14R (E)	200	120	200	970
						1000	4900 (special regs)
2.	Ohio Creek	Below Castle Creek	85B	100	12	100	50
3.	Slate River	Below Poverty Gulch	29B	50	30	50	60
4.	East River	Confluence Brush Creek	87L	100	40	100	160
						400	650 (special regs)
5.	Taylor River	Below Taylor Dam	282L, 37R	200	80	200	650
						800	2600 (special regs)
6.	Taylor Reservoir Tributaries						
	a. Taylor River	Above Taylor Reservoir	48L, 1B, 2R	100	40	100	160
						400	650 (special regs)
	b. Texas Creek		3 L	25	20	25	20
	c. Willow Creek		8R, 4B, 89L	100	13	100	50
7.	Tomichi Creek	Below Cochetopa Creek	Not Available	100	78	100	320
						400	1300 (special regs)
		Cochetopa Creek to Marshall Creek	32L, 5R	100	43	100	170
						400	700 (special regs)
		Above Marshall Creek	46L	100	15	100	60
	a. Marshall Creek		180L	200	8	200	70
	b. Quartz Creek		286L, 22R	200	23	200	180
8.	Cochetopa Creek	Below Los Pinos Creek	90L, 22R, 6B	75	35	75	110
		Los Pinos Creek to Pauline Creek	55L, 8R, 24B	100	28	100	110
						400	440 (special regs)
9.	Cebolla Creek	Below Powderhorn Creek	15L, 2R	75	36	75	110
		Powderhorn Creek to confluence E&W Fork	178B	100	31	100	130
10.	Lake Fork Gunnison	Below Gateview	53L, 14R (E)	100	63	100	250
						500	1250 (special regs)
		Gateview to Lake San Cristobal	104L, 10R	150	48	150	300
						750	1500 (special regs)
11.	Uncompahgre River	Below Ridgway Reservoir	Not Available	100	42	100	170
						500	850 (special regs)
	a. Cow Creek		Not Available	100	17	100	35

(E) Estimated total trout biomass.
Other estimates are netted biomass

R - Rainbow Trout
L - Brown Trout
B - Brook Trout

* Assumes (Annual Harvest = 20% of potential biomass.
(Weight of Fish = 3.5 trout/lb
(Catch per manhour = 0.7 (0.35 for special regs on brown trout fishery)
(One angler day = 3 hours

11.3 OPPORTUNITIES FOR IMPROVING WATERFOWL AREAS

Selected waterfowl and wetland improvement opportunities for the study area are summarized in Table 11.2.

Good opportunities for improving nesting for waterfowl exist in the Upper Gunnison Basin. The most commonly used nesting area at present is along Tomichi Creek from its confluence with the Gunnison River upstream to the town of Sargents. Ohio Creek from its confluence with the Gunnison River upstream to Baldwin is also being used for nesting.

The installation of nesting structures should be planned at approximately one structure per acre. Structures can be placed on private lands using cooperative agreements with landowners as well as on public lands. Installing nesting structures to protect goose eggs from predation by small mammals would undoubtedly improve goose reproduction rates.

One of the best areas for wetland improvements in the upper basin is in the area surrounding the confluence of Tomichi and Cochetopa Creeks. This area would benefit from the construction of small water-filled potholes in addition to nesting structures.

Good opportunities exist to improve the existing heron rookery by acquiring and restricting grazing on meadow lands just upstream of Blue Mesa Reservoir. There are opportunities at both Taylor Park Reservoir and Blue Mesa Reservoir to construct artificial nesting structures for osprey.

Waterfowl habitat in the Uncompahgre Valley could be improved by constructing ponds of 20 acres or larger. Limiting waterfowl hunting to certain days of the week during the regular hunting period should also improve hunter success. Little waterfowl nesting occurs in the Uncompahgre River Basin, but migrant populations of ducks and geese use the area annually. The migrating birds will be likely to remain in the area longer if there are more resting areas and there are periods when they are not disturbed by hunters.

TABLE 11.2

Waterfowl and Wetland Improvement Opportunities

Stream	Target Species	Practice	Opportunity for Improvement	Recommended Improvement Technique
Gunnison River (Almont to Blue Mesa Reservoir)	Great Blue Heron	Nest Site Protection From Development	Fair	Land Acquisition
Ohio Creek	Geese	Nesting Site Improvement	Good	Single Pole Nest Structures
Slate River	-	-	Limited	None at this time
East River	-	-	Limited	None at this time
Taylor River (below Taylor Park Reservoir)	-	-	Very limited	None at this time
Tomichi Creek and Tributaries	Geese Ducks	Nesting Site Improvement More Territories for Nesting Pairs	Good	Single Pole Nest Structures Pothole Blasting
Cochetopa Creek below Pauline Creek	Geese Ducks	"	Good Near Confluence with Tomichi Creek	"
Cebolla Creek	-	-	Limited	None at this time
Lake Fork of Gunnison River	-	-	Limited	None at this time
Uncompahgre River below Ridgway Dam and Tributaries	Ducks	Pond Construction	Good	Construct Ponds 20 Surface Acres

11.4 OPPORTUNITIES FOR IMPROVING WATER-BASED RECREATION

This section describes opportunities for the improvement of water-based recreation in the study area including camping, hiking, and boating. Water-based campground development opportunities were identified and tentatively sized through a variety of methods. On public lands, U.S. Forest Service (USFS), Bureau of Land Management (BLM), and National Park Service (NPS) recreation specialists based within the study area were able to offer constructive suggestions as to where additional campgrounds are needed. On lands that are currently in private ownership where fishing would be a major daytime activity for campers, initial estimates of potential campsite density were based upon providing 50 percent of the night time occupancy for the target number of anglers on the waterbody (the other 50 percent being locals or people who would stay in motels, etc.). It was assumed that the fishing season is 100 days long, that each campsite would be occupied 50 percent of the nights during the season, and that each camping party would include two anglers. The initial estimate was then checked by making a qualitative comparison with existing campground densities and occupancy rates in other similar locations in the study area.

11.4.1 Gunnison River Below Almont

As a result of the new special fishing regulations instituted on the first 5 miles of the Gunnison River below Almont in 1987, an outstanding opportunity exists to increase recreational activities on the river. When a wild rainbow trout population is successfully established on the river, angling use should be able to increase by at least five times. Although there are more than 170 public and private campsites in the vicinity, utilization of these campsites is already high. Therefore, additional public and/or private campsites will be needed. A significant opportunity should also exist for resort and motel operators to expand their summer businesses.

Opportunities for fishing from rafts are expected to increase significantly as a result of the increased capacity of the river to support

angling pressure. Boat launch and takeout areas are in need of relocation and improvement. A public boat launching area with parking is needed just below Almont. Existing takeouts on the Gunnison are difficult to negotiate with rafts during periods of low summer streamflows and are in need of improvement. To enhance boating on the Gunnison River, hazardous river obstructions should be removed. This includes removal of debris and improvement of gravel bars near irrigation diversions. This enhancement measure would be quite low in cost, but would result in the potential for many additional boating trips on the river.

Access to the Gunnison River and Tomichi Creek is almost completely lacking in the City of Gunnison. The City would benefit greatly if it could offer tourists and residents a major riverside park with recreational activities such as fishing, picnicking, wildlife observation, biking, and hiking. This would be a draw for people to extend their stays in Gunnison. The river represents an asset for the City which is underutilized at present.

11.4.2 Ohio Creek

If the fishery were improved on Ohio Creek and access was acquired, parking, picnicking, and camping areas could be developed on the creek. The area preferred for recreational development would be upstream of the confluence of Mill Creek where the scenic quality of the Ohio Creek drainage is outstanding. A multipurpose reservoir in the upper drainage would have significant recreation benefits. A reservoir in the area would have the potential of being popular for camping and fishing given the beauty of the surrounding West Elk Mountains. Without improvement of the existing fishery and improvement of access to the National Forest, opportunities for improving water-based recreation on Ohio Creek are limited.

11.4.3 East River and Slate River

An opportunity exists to develop at least ten additional campsites on the East River above Gothic on USFS lands. The USFS does not currently have funding to construct the new sites itself, however, a cooperative agreement might allow construction if funding were available from another source.

If public access was acquired along the East River or Slate River, parking, picnic, and camping areas would offer excellent water-based recreation opportunities due to the good fishing that presently exists. Construction of a hiking, biking, and horseback riding trail along the river between Almont and Crested Butte would create an outstanding recreational draw to the area.

BLM and USFS lands along the Slate River above Crested Butte have no developed recreational facilities. However, extensive day use occurs in the area by residents and tourists from Mt. Crested Butte and Crested Butte. Opportunities may exist for minor recreational improvements such as improved signage and possibly some small developed picnic grounds. Any recreation improvement program developed for the area should be prepared in close cooperation with the local officials and resort users of the area.

11.4.4 Taylor River Below Taylor Park Reservoir

The Taylor River Canyon below the Taylor Park Reservoir is the most highly developed and heavily used recreation area in the Gunnison National Forest. Because the area is popular and USFS land is available, opportunities exist to expand existing campgrounds and to construct new campgrounds. Colorado Division of Wildlife fishery biologists (Nehring, 1987) have indicated that fishing pressure could be easily doubled and perhaps increased to five times the present use with careful management without adversely affecting the existing trout fishery. Additional study would be required to determine the maximum number of additional campgrounds that could be constructed in the canyon without decreasing the high level of visitor

satisfaction that currently exists. It appears, however, that the canyon could easily accommodate an additional 25 campsites at the present time.

Opportunities to improve whitewater boating in the canyon exist. Improved boat launching and take-out facilities would benefit boating on the river. Especially needed are signs and educational materials to instruct private rafters to the proper use and respect for the river. Policies and regulations for rafting through private lands need to be clearly established and agreed to. A significant opportunity to improve rafting and kayaking on the river exists with management of releases from Taylor Park Reservoir. Flows in excess of about 400 cfs (measured at Almont) are desirable for whitewater rafting on the Taylor. Streamflows for rafting, however, are not always compatible with the generally lower flow conditions desired by fishermen. A specific management plan which addresses the needs of different recreational users on the river would be beneficial.

11.4.5 Taylor Park Reservoir and Tributaries

Demand for recreational facilities in Taylor Park is high as indicated by high occupancy rates in campgrounds throughout the drainage. Continuing improvements of the Cottonwood Pass Road and roads around the reservoir which have been ongoing for several years will continue to increase the pressure on existing facilities. The USFS is seeking funds to construct a 30-unit recreational vehicle camp on the shores of the reservoir to meet some of the demand. Improved boat launching facilities would increase recreational use of Taylor Park Reservoir. Additional opportunities exist for expansion of existing campgrounds and construction of new campgrounds on the Upper Taylor River.

11.4.6 Tomichi Creek and Tributaries

Very limited opportunities exist for improvement of recreation facilities on existing public lands on Tomichi Creek. Occupancy rates at Snowblind Campground are low and camper satisfaction is reported as only fair indicating

that construction of new campgrounds would probably meet with only limited success.

If the limited amount of public access to streams is expanded significantly through acquisition of new lands or through other methods of opening private lands to the public, the construction of additional campgrounds and picnic areas may be warranted. Campgrounds should be located in areas with suitable scenic quality such as are present upstream of the confluence with Needle Creek. Opportunities for picnic areas and parking areas should be considered anywhere that public access is made available to streams along Tomichi Creek, or lower Quartz Creek and Cochetopa Creek. Opportunities also exist on Tomichi Creek for private landowners to develop lodging and other amenities connected with the fishing resource on the creek.

On Upper Quartz Creek, there do not appear to be any opportunities for developing additional campgrounds or picnic areas since there already is an ample number of such facilities in the area.

The BLM is planning to develop up to 32 campsites on existing BLM lands on Cochetopa Creek if funding can be obtained. A cooperative development program with the BLM could help maximize recreational benefits and could provide for many additional visitors in an existing public area that doesn't provide for much developed site recreation at the present time.

The Gunnison County Planning Department places high priority upon development of a trail and bicycle path which would follow Tomichi Creek from the area of Jorgenson Park, around the east end of the airport runway, and then along the creek to its confluence with the Gunnison River. At its beginning, the trail could also cross U.S. 50 to link into the existing park and the Gunnison Chamber of Commerce Visitors Information Center.

11.4.7 Cebolla Creek

If access to Cebolla Creek can be obtained either through outright purchases, leases, or fee arrangements with private landowners, an opportunity for development of campgrounds, picnic areas, and parking areas will exist. Existing BLM and USFS campgrounds could also be expanded and improved.

An opportunity exists to provide fishing on 1-1/2 miles of Cebolla Creek on currently inaccessible BLM lands 2 miles north of the confluence with Powderhorn Creek. About 1 mile of trail or other access would need to be constructed down to or along the river. Because there are no roads or other public access available to the area at present, the study team was not able to evaluate the quality of the fishery in the 1-1/2 mile segment. It is unlikely that any developed recreation facility other than a trail could be constructed in the 1-1/2 mile segment due to the steepness of the terrain.

11.4.8 Lake Fork of the Gunnison River

If additional public access to the Lake Fork of the Gunnison below Lake San Cristobal can be obtained, excellent opportunities would exist for development of new recreational facilities due to the good fishing and excellent scenic quality of the area. Unfortunately, very little public land is currently available for recreational development. A small landlocked parcel of BLM land in Section 36 of T. 46 N., R.4 W., New Mexico Principal Meridian would provide an excellent site for a campground on the banks of the Lake Fork if access could be obtained across a small strip of private land which blocks entry from Highway 149.

Boating on the Lake Fork could be improved by the removal of cables and fences across the river and the improvement of boat launching and takeout areas.

11.4.9 Blue Mesa Reservoir and Small Tributaries

The National Park Service has identified opportunities for construction of a new marina and boat ramp and new campgrounds on Blue Mesa Reservoir. Minor improvement opportunities have also been identified for the Bay of Chickens windsurfing area on the reservoir. The NPS staff has indicated that these opportunities will be pursued after the Curecanti National Recreation Area's enabling legislation has been transferred to the National Park Service and when funding becomes available.

The USFS is expanding and improving its campgrounds on Soap Creek. No other opportunities for improvement or construction of new recreation facilities on the small tributaries to Blue Mesa Reservoir were identified.

11.4.10 Uncompahgre River

The Colorado Division of Parks and Outdoor Recreation is currently constructing full-service campgrounds with a total of 280 units, a picnic area, marina, trails, and park headquarters at the Ridgway State Park. As a result, no additional opportunities for additional water-based campground facilities have been identified at this time.

Montrose, Ridgway, and Ouray would benefit from the development of a recreational corridor which would connect those communities with Ridgway Reservoir. The corridor, a bike, hike, jog, fish, and raft area, would follow abandoned Denver and Rio Grande Western Railroad tracks along the Uncompahgre River. This would be a draw for visitors to extend their stays in the Uncompahgre Valley. A citizens committee in Montrose is investigating different aspects of the project including funding sources and acquisition of rights-of-way.

Opportunities exist also for the City of Delta to develop riverside recreational improvements adjacent to the Gunnison River.

11.5 OPPORTUNITIES FOR IMPROVING PUBLIC ACCESS

Lack of public access to streams is one of the biggest limiting factors to water-based recreation in the study area. Of 385 stream miles on the selected list of streams being considered for enhancement, only 110 miles (29 percent) lie on public lands. Of the remaining 275 miles of streams which lie on private lands, less than 30 miles have some sort of formal arrangement for allowing public access such as a fishing easement, annual lease, fish stocking agreement, or arrangement for payment of daily fees. If the headwater stretches of the selected streams are eliminated from the total stream mileage, the limitations on public access become even more noteworthy. Less than 70 miles (22 percent) of the remaining 315 miles of downstream segments lie on public lands.

The purchasing of public access, whether as land in fee title or as perpetual fishing easements adjacent to streams by conservation organizations or public entities, is a useful approach to increase public access. In this report, it has been assumed that acquisition of land for public recreation purposes would only occur if there is a willing seller, i.e., that condemnation would not be considered. A cursory effort has been made to estimate current selling prices for lands adjacent to streams, and to assess the feasibility of obtaining public access for recreation on major stream drainages in the study area, the results of which are summarized in Table 11.3.

TABLE 11.3

Approximate Cost and Feasibility of Acquiring Recreation Access

	Approximate Purchase Price per Stream Mile	Availability for Purchase		Possibility of Short-Term Leases
		More than 1/4 Mile	Less than 1/4 Mile	
1. Gunnison River	$350,000 - $1,600,000	Poor-Fair	Good	Fair
2. Ohio Creek	$160,000 - $320,000	Good	Good	Good
3. East and Slate Rivers	Not available	Poor	Fair	Good
4. Taylor River	$500,000 - $1,000,000	Poor	Poor	Poor
5. Tomichi Creek	$115,000	Good	Good	Good
6. Quartz Creek	$115,000	Fair	Good	Fair
7. Cochetopa Creek	$115,000	Fair	Good	Fair
11. Cebolla Creek	$160,000	Good	Good	Good
9. Lake Fork of the Gunnison River	$500,000	Poor	Fair	Poor
10. Uncompahgre River	$160,000	Poor-Fair	Fair	Poor-Fair

Leases of annual fishing easements in the study area are currently priced at between $1000 and $2000 per stream mile per year based upon location, quality of fishing, and other factors. Where a daily fee structure is used to charge for access on private lands, typical rod fees paid to the landowner are $10 per person per day. In order for the landowner to be successful, careful attention must be given to development and maintenance of refuse collection and sanitary facilities, fencing and gate systems, fee collection, policing, and landowner liability.

11.6 SUMMARY OF FISHERY AND RECREATION OPPORTUNITIES

Major improvement opportunities for fisheries, waterfowl, recreation and public access are summarized in Table 11.4

TABLE 11.4

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Gunnison River (Almont to Blue Mesa Res.)	Fence and restore streambank vegetation for wild trophy rainbow	$8,000 - $15,000 per mile	Needed on private lands below National Forest Boundary
Target for Angler use	Improve instream habitat for wild trophy rainbow	$40,000 - $200,000 per mile	Needed on private lands from diversions in Sec. 8, T5ON, R85W, N.M.P.M. to Blue Mesa Reservoir
Normal Regulations 970 Angler Days per mile per year (Ad/mi/yr)			
Special Regulations 4900 AD/mi/yr	Manage instream flow for wild trophy rainbow	Not Available (N.A.)[1)]	
	Improve heron rookery near confluence S. Beaver Creek	$4,000 per mile for fencing where needed	Presently private land
	Develop up to 25 campsites for each mile of acquired stream access	$100,000 - $250,000 per mile for construction	Presently private land
	Provide 3 improved raft access points	$20,000 ea. for construction	On existing public lands or easements
	Gunnison City riverside park and trails	N.A.	Presently private land
	Purchase public access to trophy rainbow trout fishery	$350,000 - $1,600,000 per mile	Poor to fair feasibility of acquisition of segments over 1/4 mile long
	Short term lease of access to trophy rainbow trout fishery	No comparable leases available	Fair feasibility of acquisition
Ohio Creek (confluence Castle Creek to confluence Gunnison River)	Fence and restore streambank vegetation	$8,000 - $15,000 per mile	Presently private land
	Improve instream habitat	$15,000 - $35,000 per mile	Presently private land
Target for Angler use			
Normal Regs. 50 AD/mi/yr	Stock 50 lb/ac/yr hatchery trout	$175 per mile per year	Presently private land
	Improve nesting habitat for geese	$120 per acre for structures	Presently private land
	Develop up to .25 campsites per mile of acquired and improved stream access	$1,000 - $3,000 per mile for construction	Presently private land

TABLE 11.4 (Continued)

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Ohio Creek (Continued)	Purchase public access along stream	$160,000 - $320,000 per mile	Good feasibility of acquisition of segments over 1/4 mile long
	Short term lease of access to fishing	No comparable leases available	Good feasibility of acquisition
East River (confluence Brush Creek to confluence Taylor River)	Fence and restore streambank vegetation for wild brown trout fishery	$8,000 - $15,000 per mile	Nearly all on private lands
Target for Angler use	Improve instream habitat for wild brown trout fishery	$10,000 - $25,000 per mile	Nearly all on private lands
Normal Regs. 160 AD/mi/yr Special Regs. 650 AD/mi/yr	Continue use of special regulations to suit angler preferences and reduce fishing pressure	Negligible	Nearly all on private lands
	Reduce spring flood to improve rainbow spawning	N.A.[1)]	Nearly all on private lands
	Develop up to 3 campsites per mile of acquired stream access	$12,000 - $30,000 per mile for construction	Nearly all on private lands
	Develop streamside trail from Almont to Crested Butte	$15,000 per mile gravel construction	Would require participation of many landowners
	Purchase public access to reduce fishing pressure on wild brown trout	No comparables available	Poor feasibility of acquisition of segments over 1/4 mile long
	Short term lease of access to wild brown trout fishing	$1,000 - $2,000 per mile per year	Good feasibility of acquisition
East River (confluence Rustler Gulch to confluence Brush Creek)	Stock 50 lb/ac/yr hatchery trout	$215 per mile per year	
	Develop 10 additional campsites on USFS lands	$35,000 - $70,000	
	Purchase public access along stream	No comparables available	Poor feasibility of acquisition of segments over 1/4 mile long
	Short term lease of access to fishing	$1,000 - $2,000 per mile per year	Good feasibility of acquisition

TABLE 11.4 (Continued)

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Slate River (confluence Poverty Gulch to confluence East River)	Improve instream habitat	$10,000 - $25,000 per mile	
Target for Angler use	Stock 50 lb/ac/yr hatchery trout	$215 per mile per year	
Normal Regs. 60 AD/mi/yr	Purchase public access	No comparables available	Poor feasibility of acquisition of segments over 1/4 mile long
	Short term lease of access to fishing	$1,000 - $2,000 per mile per year	Good feasibility of acquisition
Taylor River (Taylor Park Reservoir to Almont	Improve stream habitat	$10,000 - $50,000 per mile	
Target for Angler Use	Increase water temperature with multilevel outlet works	$15,000,000	
Normal Regs. 650 AD/mi/yr	Manage instream flow	N.A.[1)]	
Special Regs. 2600 AD/mi/yr	Improve brown trout fishery below confluence Lottis Creek with special regulations	Negligible	
	Stock 50 lb/ac/yr or more hatchery trout on put and take sections	$700 or more per mile per year	
	Develop 25 additional campsites on USFS lands	$100,000 - $250,000	
	Provide 2 improved raft access points on USFS lands	$20,000 ea.	
	Manage instream flow for white-water boaters	N.A.[1)]	
	Obtain public access to outstanding trophy brown trout fishery below Taylor Park Dam	$500,000 to $1,000,000 per mile to purchase all land along stream	Poor feasibility of acquisition
	Short term lease of access to trophy brown trout fishery	No comparables available	Poor feasibility of acquisition

TABLE 11.4 (Continued)

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Taylor Park Reservoir	Increase shallow water areas by raising dam	N.A.[1)]	
	Develop 30 recreational vehicle campsites on USFS lands on shores of reservoir	$145,000 projected	
Taylor River (Headwaters to Taylor Park Reservoir)	Improve stream habitat	$10,000 - $25,000 per mile	
Target for Angler use	Establish special regulations	Negligible	
Normal Regs. 160 AD/mi/yr	Stock 50 lb/ac/yr hatchery trout	$350 per mile per year	
Special Regs. 650 AD/mi/yr	Develop 10 additional campsites on USFS lands	$35,000 - $70,000	May put too much pressure on fishery unless accompanied by fishery improvements including additional stocking or special regulations
Tomichi Creek (confluence Marshall Creek to confluence Gunnison River), Quartz Creek (confluence Gold Creek to confluence Tomichi Creek), and Cochetopa Creek (confluence Bead Creek to confluence Tomichi Creek)	Fence and restore streambank vegetation	$8,000 to $15,000	Presently private land
	Improve instream habitat	$20,000 - $60,000 per mile	Presently private land
	Reduce nutrient inflow	N.A.	Presently private land
Targets for Angler use	Improve wetland for waterfowl near confluence Tomichi Creek and Cochetopa Creek	$4,000 per mile for fencing $120 per acre for nesting structures $1600 per acre for potholes	Presently private land
Normal Regs. 110-320 AD/mi/yr			
Special Regs. 700-1300 AD/mi/yr	Develop up to 3 campsites per mile of acquired stream access	$12,000 - $30,000 per mile for construction	Presently private land
	Develop Gunnison City riverside park and trails	N.A.	Presently private land
	Purchase public access along stream	$115,000 per mile	Good feasibility of acquisition of segments over 1/4 mile long
	Short term lease of fishing access	N.A.[1)]	Good feasibility of acquisition

TABLE 11.4 (Continued)

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Cochetopa Canyon, Tomichi Creek (above Sargents), Quartz Creek, and (above confluence Gold Creek) Marshall Creek Targets for Angler use Normal Regs. 60-180 AD/mi/yr	Improve instream habitat with pooling structures	$10,000 - $25,000 per mile	
	Develop 32 campsites in Cochetopa Canyon on BLM lands	$100,000 - $200,000	
	Stock 50 lb/ac/yr hatchery trout	$130 per mile per year	
Cebolla Creek (confluence E&W Fork to Blue Mesa Reservoir Targets for Angler use Normal Regs. 110-130 AD/mi/yr	Fence and restore streambank vegetation	$8,000 - $15,000 per mile	Presently private land
	Improve instream habitat	$20,000-$45,000 per mile	Presently private land
	Stock 50 lb/ac/yr of hatchery trout	$260 per mile per year	Presently private land
	Develop up to 1 campsite per mile of acquired and improved stream access	$3500 - $10,000 per mile for construction	Presently private land
	Develop 1 mile of trail to 1-1/2 miles of inaccessible stream on BLM land	N.A.[1)]	
	Purchase public access along stream	$160,000 per mile	Good feasibility of acquisition of segments over 1/4 mile long
	Short term lease of fishing access	No comparables available	Good feasibility of acquisition

TABLE 11.4 (Continued)

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Lake Fork of the Gunnison River (Lake San Cristobal to Blue Mesa Reservoir)	Improve instream habitat with boulders	$10,000 - $25,000 per mile	Need is almost all on private lands above Red Bridge Campground
Targets for Angler use	Institute special fishing regulations to create trophy rainbow fishery	Negligible	
Normal Regs. 250-300 AD/mi/yr			
Special Regs. 1250-1500 AD/mi/yr	Stock 50 lb/ac/yr of hatchery trout in public put and take areas	$475 per mile per year	
	Develop up to 6 campsites per mile of acquired stream access	$24,000 - $60,000 per mile for construction	Presently private land
	Provide 2 improved raft access points	$20,000 ea for construction	
	Purchase public access along stream to relieve fishing pressure	$500,000 per mile	Poor feasibility of acquisition of segments over 1/4 mile long
	Short term lease of fishing access	$2,000 per mile	Poor feasibility of acquisition
Blue Mesa Reservoir and Tributaries	Introduce trophy size rainbow trout to reservoir	N.A.[1)]	
	Fence and restore streambank vegetation on spawning tributaries	$8,000 - $15,000 per mile	
	Improve pool habitat in spawning tributaries	$5,000 - $25,000 per mile	
	Eliminate fish passage barriers under U.S. Highway 50	N.A.[1)]	
	Improve shallow areas of reservoir	$15,000 - $150,000 per acre	
	Development of additional marina, boat launching facility and campgrounds on Blue Mesa Reservoir by National Park Service	Future Park Service Project	
	Improve Bay of Chickens wind surfing area on Blue Mesa Reservoir	Future Park Service Project	

TABLE 11.4 (Continued)

MAJOR FISHERY AND RECREATION IMPROVEMENT OPPORTUNITIES

Waterbody	Improvement Opportunity	Typical Cost Range	Comment
Uncompahgre River (Ridgway Reservoir to Gunnison River)	Fence and restore vegetation	$8,000 - $15,000 per mile	Presently private land
Target for Angler use	Institute special fishing regulations to protect developing tailwater fishery	Negligible	
Normal Regs. 170 AD/mi/yr	Improve instream habitat	$10,000 - $35,000 per mile	Presently private land
Special Regs. 850 AD/mi/yr	Construct 20+ acre ponds for waterfowl	N.A. 1)	Presently private land
	Limit number of days per week of waterfowl hunting	Negligible	
	Purchase public access along stream	$160,000 per mile	Poor-fair feasibility of acquisition of segments over 1/4 mile long
	Short term lease of fishing access	No comparables available	Poor-fair feasibility of acquisition

1) Cost to be estimated as a part of subsequent tasks if the improvement opportunity survives screening

11.7 SCREENING OF RECREATION OPPORTUNITIES AND COMPONENTS

11.7.1 Screening Criteria

To be effective, a screening criteria must take into account the objectives to be met by the elements or plans being screened. The overall objective of this study is stated as follows:

> Provide high quality recreation opportunities that will result in increased tourism and related economic benefits to the study area and to the State of Colorado.

This target objective for alternative plans related to recreation is broad in nature and therefore the following subset of target objectives for use in screening recreation components were established:

1. Provide one or more "unique or trophy fisheries" in the study area.

2. Provide improved access to existing high quality fisheries located within private lands.

3. Provide campgrounds and trails at locations where they will accommodate water-based recreation users.

4. Provide improved river-based recreation opportunities.

5. Improve waterfowl habitat and wetland areas at several locations in the study area.

6. Distribute recreation improvements throughout the study area, although concentration of improvements may occur in certain areas where opportunities are the greatest.

11.7.2 Results of Screening

The comprehensive list of improvement opportunities presented in Table 11.4 was reviewed and evaluated. Recreation components with the most obvious potential for meeting one or more of the recreation target objectives were selected from Table 11.4 for detailed screening. These selected components were screened and ranked according to the following criteria:

Potential economic benefit
Potential for obtaining access
Condition of the existing site with regard to its target objective
Potential for major environmental impact
Public support
Relative cost

Table 11.5 presents the results of the comparative screening of recreation components. Table 11.6 lists the components which received a "high" overall rank in the screening process and therefore were retained for further study and possible future development. The components listed in Table 11.6 therefore were used in plan formulation.

All of the components shown in Table 11.6 are considered to have the potential for development at some point in time. However, implementation of this entire list in one development project may be overly ambitious from the viewpoint of a practical allocation of resources. Therefore, the list was reviewed and evaluated from the standpoint of developing the components in stages. Table 11.7 presents the same list but subdivides the list into the following two categories:

- High Priority Components Recommended for First Phase Development
- Lower Priority Components Recommended for Development during Future Phases.

The intent of subdividing the components is that during plan formulation, a more limited list of recreation components should be included in some alternative plans to reflect a staged approach to development of recreation components.

All of the components listed in Table 11.6 require additional study, analysis and refinement before being implemented. Two of the recommended components are unique, however in that those components consists solely of performing further studies after which a decision on whether or not to recommend implementation would be made. These two components are discussed below.

Blue Mesa Large Size Trout

The possibility of introducing a new variety of rainbow trout in Blue Mesa Reservoir which can reach 40 pounds or more, such as the Gerrard strain of Kamloops trout, has been identified as a potential action which is relatively low cost, has great potential to garner national publicity and therefore, could possibly result in significant economic benefit to the surrounding region. The Study Team recognizes that introduction of a new, large-sized trout variety into an already good quality fishery carries a certain risk with it and therefore the recommended component is to perform adequate studies of the risks involved before recommending implementation on either a pilot or full scale basis.

The recommended studies should address the potential for successfully introducing the new variety of trout, the effect of the new variety on existing species, and the potential impact on present angler days at Blue Mesa. The Colorado Division of Wildlife is responsible for the management of the State's wildlife resources and therefore, will ultimately make the decision regarding implementation of this component. The research and studies required to reach that conclusion should therefore be carried out by the CDOW or in close cooperation with them.

Uncompahgre River Trout Fishery

With the construction of Ridgway Dam on the Uncompahgre River, it is believed by many that the water quality below the dam will become suitable to support a good trout fishery. If that occurs, then it would be beneficial to take appropriate steps to insure that a high quality trout fishery becomes established (appropriate reservoir releases for instream flow, stocking appropriate trout species, special regulations, improve stream habitat, etc.). The recommended component for this particular opportunity is to monitor water quality and trout population below the dam and if conditions improve as expected, implement an action plan to establish and support a good quality trout fishery in the river.

11.8 PRELIMINARY COST ESTIMATES

A preliminary cost estimate was prepared for all the components identified as being recommended for inclusion in alternative plans. Table 11.7 presents the total construction cost, annual lease costs where appropriate, and annual operation and maintenance cost for each component. When these components are included in alternative plans, these costs will be adjusted to include interest during construction and financing charges.

TABLE 11.5

SCREENING OF RECREATION COMPONENTS

TARGET OBJECTIVE Develop Unique/Trophy Fisheries

COMPONENT	RANKING FACTOR																		4.) OVERALL RANK
	ECONOMIC POTENTIAL BENEFIT			1.) POTENTIAL FOR OBTAINING ACCESS			2.) EXISTING SITE CONDITION			POTENTIAL ENVR. IMPACTS			PUBLIC SUPPORT			RELATIVE COST			
	HIGH	MOD.	LOW	GOOD	FAIR	POOR	GOOD	FAIR	POOR	LOW	MOD.	HIGH	GOOD	FAIR	POOR	LOW	MOD.	HIGH	
Gunnison River (Almont to Blue Mesa)																			
Manage flows for wild rainbow trout	X				X		X 3.)	X 3.)		X			X			X			HIGH
Improve Access (Private Sections)	X				X		X	X		X			X					X	MOD.
Improve Access (Public Sections)	X			X			X	X		X			X			X			HIGH
Improve Trout Habitat	X				X		X	X		X			X					X	MOD.
Improve Irrigation Diversions	X			X			X	X		X			X				X		HIGH
Taylor River (4 miles below dam)																			
Introduce Wild Rainbow Trout	X					X	X			X			X			X			5.) HIGH
Establish Special Regulations	X					X	X			X			Not Available			X			HIGH
Manage Flows for Wild Rainbow Trout	X					X	X			X			X			X			HIGH
Improve Public Access	X					X	X			X			X					X	MOD.
Provide Access to 1/4 Mi. of Public Land Below Dam	X				X		X			X			X			X			HIGH
Lake Fork of the Gunnison																			
Improve Trout Habitat	X					X	X			X				X				X	LOW
Establish Special Regulations	X					X	X			X				X			X		LOW
Blue Mesa Reservoir																			
Study Introduction of Large Trout Variety	X			X			X			Unknown			X			X			HIGH
Uncompahgre River																			
Develop Trout Fishery	X					X			X	X			X			X			HIGH

1 RELATES TO OBTAINING ACCESS TO PRIVATELY OWNED PROPERTY UNLESS OTHERWISE STATED IN COMPONENT DESCRIPTION.
2 RELATES TO SITE CONDITIONS PERTINENT TO THE TARGET OBJECTIVE UNDER CONSIDERATION.
3 WHERE MORE THAN ONE CATEGORY IS MARKED, IT DENOTES THAT SOME STREAM SEGMENTS FALL IN ONE WHILE OTHER SEGMENTS FALL IN THE OTHER CATEGORY.
4 COMPONENTS RECIEVING AN OVERALL RANK OF HIGH ARE RETAINED FOR IMPLEMENTATION, OTHERS WERE ELIMINATED FROM CONSIDERATION.
5 CDOW HAS STARTED IMPLEMENTATION SINCE STUDY INCEPTION THEREFORE ELIMINATED FROM CONSIDERATION.

TABLE 11.5 (continued)

SCREENING OF RECREATION COMPONENTS

TARGET OBJECTIVE: Improve Camping and Hiking Opportunities

COMPONENT	RANKING FACTOR																		4.) OVERALL RANK
	ECONOMIC POTENTIAL BENEFIT			1.) POTENTIAL FOR OBTAINING ACCESS			2.) EXISTING SITE CONDITION			POTENTIAL ENVR. IMPACTS			PUBLIC SUPPORT			RELATIVE COST			
	HIGH	MOD	LOW	GOOD	FAIR	POOR	GOOD	FAIR	POOR	LOW	MOD.	HIGH	GOOD	FAIR	POOR	LOW	MOD.	HIGH	
Gunnison River Campsites	X			X			X	X		X			Not Available				X		HIGH
Ohio Ck. Campsites			X	X			X	X		X			Not Available				X		LOW
East River Campsites		X			X		X			X			Not Available				X		5.) MOD.
Trail-Almont to Crested Butte	X				X		X			X			Not Available				X		HIGH
Taylor River Campsites (Public Lands)	X			X			X			X			X				X		HIGH
Taylor Park Reservoir Campsites (Public Lands)	X			X			X			X			Not Available			X			HIGH
Tomichi Ck. Below Marshall Ck.-Campsites		X		X				X		X			Not Available				X		MOD.
Quartz Ck. Below Gold Ck.-Campsites		X		X				X		X			Not Available				X		MOD.
Tomichi Ck. Streamside Park & Trail	X			Not Available				X		X			X				X		HIGH
Cochetopa Ck. Campsites-Below Canyon			X	X				X		X			Not Available				X		LOW
Cochetopa Ck. Campsites-In Canyon (Public Lands)		X		X			X			X			Not Available			X			HIGH
Cebolla Ck. Campsites			X	X			X			X			Not Available				X		LOW
Cebolla Ck. Access Trail to Stream			X	X				X		X			Not Available				X		LOW
Lake Fork of the Gunnison Campsites	X					X	X			X			Not Available				X		MOD.
Uncompahgre River Trail		X		X				X		X			X				X		HIGH

1. RELATES TO OBTAINING ACCESS TO PRIVATELY OWNED PROPERTY UNLESS OTHERWISE STATED IN COMPONENT DESCRIPTION.
2. RELATES TO SITE CONDITIONS PERTINENT TO THE TARGET OBJECTIVE UNDER CONSIDERATION.
3. WHERE MORE THAN ONE CATEGORY IS MARKED, IT DENOTES THAT SOME STREAM SEGMENTS FALL IN ONE WHILE OTHER SEGMENTS FALL IN THE OTHER CATEGORY.
4. COMPONENTS RECIEVING AN OVERALL RANK OF HIGH ARE RETAINED FOR IMPLEMENTATION, OTHERS WERE ELIMINATED FROM CONSIDERATION.
5. COMBINED WITH TRAIL AND RETAINED FOR FUTHER STUDY.

TABLE 11.5 (continued)

SCREENING OF RECREATION COMPONENTS

TARGET OBJECTIVE Improve Access to Existing High Quality Fisheries

COMPONENT	RANKING FACTOR																		4.) OVERALL RANK
	ECONOMIC POTENTIAL BENEFIT			1.) POTENTIAL FOR OBTAINING ACCESS			2.) EXISTING SITE CONDITION			POTENTIAL ENVR. IMPACTS			PUBLIC SUPPORT			RELATIVE COST			
	HIGH	MOD.	LOW	GOOD	FAIR	POOR	GOOD	FAIR	POOR	LOW	MOD.	HIGH	GOOD	FAIR	POOR	LOW	MOD.	HIGH	
Short-term Lease of Private Lands for Public Access																			
Gunnison River	X				X		X	X		X			X				X		MOD.
Ohio Creek			X	X				X	X	X			X			X			LOW
East River		X		X			X			X			X			X			HIGH
Slate River			X	X				X		X			X				X		MOD.
Taylor River	X					X	X			X			X					X	LOW
Tomichi Creek:																			
Below Cochetopa Ck.	X			X			X	X	X	X			X			X			HIGH
Cochetopa Ck. to Marshall Ck.		X		X			X	X	X	X			X			X			HIGH
Above Marshall Ck.			X		X		X			X			X			X			LOW
Marshall Ck.			X		X		X			X			X			X			LOW
Quartz Creek		X		X			X			X			X			X			HIGH
Cochetopa Creek																			
Below Canyon			X	X				X		X			X			X			MOD.
Above Canyon			X		X		X	X		X			X				X		MOD.
Cebolla Creek			X	X			X	X	X	X			X			X			MOD.
Lake Fork of the Gunnison		X				X	X			X			X				X		MOD.
Cow Creek			X	Not Available				X	X	X			X			Not Available			LOW
Uncompahgre River		X			X	X	Requires Monitoring			X			X			Not Available			MOD.

1. RELATES TO OBTAINING ACCESS TO PRIVATELY OWNED PROPERTY UNLESS OTHERWISE STATED IN COMPONENT DESCRIPTION.
2. RELATES TO SITE CONDITIONS PERTINENT TO THE TARGET OBJECTIVE UNDER CONSIDERATION.
3. WHERE MORE THAN ONE CATEGORY IS MARKED, IT DENOTES THAT SOME STREAM SEGMENTS FALL IN ONE WHILE OTHER SEGMENTS FALL IN THE OTHER CATEGORY.
4. COMPONENTS RECIEVING AN OVERALL RANK OF HIGH ARE RETAINED FOR IMPLEMENTATION, OTHERS WERE ELIMINATED FROM CONSIDERATION.

TABLE 11.5 (continued)

SCREENING OF RECREATION COMPONENTS

TARGET OBJECTIVE: Improve Waterfowl Habitat and Wetland Areas

COMPONENT	RANKING FACTOR																		4.) OVERALL RANK
	ECONOMIC POTENTIAL BENEFIT			1) POTENTIAL FOR OBTAINING ACCESS			2.) EXISTING SITE CONDITION			POTENTIAL ENVR. IMPACTS			PUBLIC SUPPORT			RELATIVE COST			
	HIGH	MOD.	LOW	GOOD	FAIR	POOR	GOOD	FAIR	POOR	LOW	MOD.	HIGH	GOOD	FAIR	POOR	LOW	MOD.	HIGH	
Gunnison River Heron Rookery			X	X			X			X			X			X			LOW
Ohio Ck. Waterfowl Nesting Habitat			X	X				X		X			X			X			LOW
Wetland at Confluence of Tomichi and Cochetopa Creeks			X	X				X		X			X				X		LOW
Uncompahgre Valley Waterfowl Habitat			X	X			X			X			X				X		LOW
Restrictive Waterfowl Hunting Regulations			X	Not Applicable			Not Applicable			X			Unknown			X			LOW

1 RELATES TO OBTAINING ACCESS TO PRIVATELY OWNED PROPERTY UNLESS OTHERWISE STATED IN COMPONENT DESCRIPTION.
2 RELATES TO SITE CONDITIONS PERTINENT TO THE TARGET OBJECTIVE UNDER CONSIDERATION
3 WHERE MORE THAN ONE CATEGORY IS MARKED, IT DENOTES THAT SOME STREAM SEGMENTS FALL IN ONE WHILE OTHER SEGMENTS FALL IN THE OTHER CATEGORY.
4 COMPONENTS RECIEVING AN OVERALL RANK OF HIGH ARE RETAINED FOR IMPLEMENTATION, OTHERS WERE ELIMINATED FROM CONSIDERATION.

TABLE 11.5 (continued)

SCREENING OF RECREATION COMPONENTS

TARGET OBJECTIVE: Provide Improved Stream Boating Opportunities

COMPONENT	RANKING FACTOR																		4.) OVERALL RANK
	ECONOMIC POTENTIAL BENEFIT			1.) POTENTIAL FOR OBTAINING ACCESS			2.) EXISTING SITE CONDITION			POTENTIAL ENVR. IMPACTS			PUBLIC SUPPORT			RELATIVE COST			
	HIGH	MOD.	LOW	GOOD	FAIR	POOR	GOOD	FAIR	POOR	LOW	MOD.	HIGH	GOOD	FAIR	POOR	LOW	MOD.	HIGH	
Gunnison River Boat and Raft Access Points (Public Lands)	X			X			X			X			X			X			HIGH
Taylor River Boat and Raft Access Points (Public Lands)	X			X			X			X			X			X			HIGH
Improve Taylor River Low Flow Rafting Potential	X			X			X			X				X			X		HIGH
Lake Fork of the Gunnison Boat and Raft Access Points (Public Lands)		X				X		X		X				X		X			LOW

1. RELATES TO OBTAINING ACCESS TO PRIVATELY OWNED PROPERTY UNLESS OTHERWISE STATED IN COMPONENT DESCRIPTION.
2. RELATES TO SITE CONDITIONS PERTINENT TO THE TARGET OBJECTIVE UNDER CONSIDERATION.
3. WHERE MORE THAN ONE CATEGORY IS MARKED, IT DENOTES THAT SOME STREAM SEGMENTS FALL IN ONE WHILE OTHER SEGMENTS FALL IN THE OTHER CATEGORY.
4. COMPONENTS RECIEVING AN OVERALL RANK OF HIGH ARE RETAINED FOR IMPLEMENTATION, OTHERS WERE ELIMINATED FROM CONSIDERATION.

TABLE 11.6

Recreation Components Recommended For Inclusion In Alternative Plans

TARGET OBJECTIVE: UNIQUE/TROPHY FISHERY

Water Body	Component	Proposed Action
Gunnison River - Almont to Blue Mesa Reservoir	Trophy-size, wild rainbow trout stream fishery	Manage instream flows, improve access on public sections and improve irrigation diversions
Taylor River	Trophy-size, wild rainbow trout stream fishery	Manage instream flows, institute special regulations and provide public access to 1/4 mile reach below the dam.
Blue Mesa Reservoir	Study potential for introduction of large-size trout species	Research the desirability of introducing Kamloops trout on a trial basis and implement if results warrant.
Uncompahgre River below Ridgway Reservoir	Develop trout fishery	Monitor conditions and implement appropriate plan when conditions warrant.

TARGET OBJECTIVE: IMPROVE ACCESS EXISTING GOOD QUALITY FISHERIES

Water Body	Component	Proposed Action
East River	Provide public access	Arrange for public access to 3 miles of present private property through short term leases.
Tomichi Creek (Marshall Creek to Gunnison River)	Provide public access	Arrange for public access to 8 miles of present private property through short term leases
Quartz Creek	Provide public access	Arrange for public access to 3 miles of presently private property through short term leases.

TARGET OBJECTIVE: PROVIDE IMPROVED STREAM BOATING OPPORTUNITIES

Water Body	Component	Proposed Action
Taylor River	Improve put-in and take-out points	Provide 2 raft and boat access points.
Taylor River	Improve low flow rafting potential	Modify selected reaches of streambed and manage Taylor Reservoir releases to improve rafting.
Gunnison River - Almont to Blue Mesa Reservoir	Improve put-in and take-out points	Provide 3 raft and boat access points.

TARGET OBJECTIVE: IMPROVE WATERFOWL HABITAT AND WETLAND AREAS

Waterbody	Component	Proposed Action
No Economically Beneficial Components Identified (Will Not Draw Out-of-Basin Visitors)		

TARGET OBJECTIVE: IMPROVE CAMPING AND HIKING OPPORTUNITIES

Waterbody	Component	Proposed Action
Gunnison River - Almont to Blue Mesa Reservoir	Provide campgrounds	Develop 25 campsites
East River	Provide campgrounds and trails	Develop 10 campsites and 18 miles of trail between Almont and Crested Butte.
Taylor River	Provide campgrounds	Develop 25 campsites.
Taylor Park Reservoir	Provide campgrounds	Develop 30 RV campsites.
Tomichi Creek	Provide trail	Develop 4 miles of streamside trail through City of Gunnison, 3-acre park and 20 picnic sites.
Cochetopa Creek within Cochetopa Canyon	Improve existing campgrounds	Improve 32 existing primitive campsites.
Uncompahgre River	Provide trails	Develop 17 mile trail from Montrose to Ridgway Reservoir.

TABLE 11.7

Categorization of Recommended Recreation Components
(See Table 5.3 for Description of the Components Listed Below)

HIGH PRIORITY COMPONENTS RECOMMENDED FOR PHASE ONE DEVELOPMENT

Component	Remarks
Gunnison River trophy-size, wild rainbow trout fishery	High potential for economic benefit and national publicity. Low cost.
Taylor River trophy-size, wild rainbow trout fishery.	Same as above.
Blue Mesa Reservoir large-size trout variety.	Same as above.
East River public access to 3 miles of stream	Moderate potential for economic benefit with. relatively low cost.
Tomichi Creek public access to 8 miles below Marshall Creek.	Good potential benefit.
Improve low flow rafting potential on the Taylor River.	Improvement of this existing, good quality rafting stream will provide moderate direct economic benefits, significant indirect benefits and favorable publicity for the region.
Improve raft and boat put-in and take-out points on Gunnison River.	Relatively high potential benefit assuming wild rainbow trout fishery develops.
Develop 25 campsites along Taylor River	Presently very popular area and existing campgrounds experience high utilization. Suitable public lands may exist therefore no land acquisition costs.
Improve 32 existing primitive campsites in Cochetopa Canyon	Relatively low cost. Scenic location.
Develop Uncompahgre River trail from Montrose to Ridgway Reservoir	Majority of ROW already in public domain, good public support, potential high indirect economic benefit to area.

COMPONENTS RECOMMENDED FOR DEVELOPMENT IN FUTURE PROJECT PHASES

Component	Remarks
Quartz Creek public access to 3 miles of stream.	Moderate benefit. Less popular than East River.
Improve raft and boat put-in and take-out points on Taylor River.	U.S. Forest Service presently has program underway. Defer any action until their program is completed and the need is re-evaluated.
Develop campsites along the Gunnison River from Almont to Blue Mesa Reservoir.	Relatively higher cost due to land acquisition costs.
East River streamside trail and campsites.	Difficulty expected in acquiring land.
Develop 30 RV campsites at Taylor Reservoir	U.S. Forest Service presently has program underway. Defer action and re-evaluate demand after that program is complete.
Develop streamside trail and park along Tomichi Creek through City of Gunnison.	Would entail purchase of practically all land involved at relatively high cost. Some difficulty expected in acquiring land.
Uncompahgre River Trout Fishery	CDOW and USBR presently have program underway.

TABLE 11.8

Estimated Cost of Recreation Components
(January 1, 1989 Price Level)

Component	Total Construction Cost	Annual Lease Cost	Annual O&M Cost
Manage instream flows, improve access on public sections and improve irrigation diversions on Gunnison River to develop a trophy-size, wild rainbow trout fishery.	$ 150,000.00	N/A[1]	$3,000.00 Annual cost is the cost of monitoring instream flows to determine appropriate values.
Manage instream flows, institute special regulations and provide public access on 1/4 mile of stream below Tayler Park Dam to develop a trophy-size, wild rainbow trout fishery in the Upper Taylor River.	$ 25,000.00 This is cost of implementing the special regulations	N/A	$6,000.00
Study the potential for introducing large size trout in Blue Mesa Reservoir.	--	N/A	--
Monitor conditions in the Uncompahgre River below Ridgway Dam to access potential of developing a trout fishery.	--	N/A	--
Provide public access to 3 miles of private property on the East River (short-term leases)	N/A	$4,500.00	Assumes lessor responsible
Provide public access to 8 miles of private property on Tomichi Creek between Marshall Creek and the Gunnison River (short-term leases).	N/A	$12,000.00	Assumes lessor responsible
Provide public access to 3 miles of private property on Quartz Creek. (short term leases).	N/A	$ 4,500.00	Assumes lessor responsible
Provide two raft and boat access points on the Taylor River.	$ 60,000.00	N/A	$ 2,000.00
Modify selected stream reaches and manage Taylor Reservoir releases to improve Taylor River rafting during low flow periods.	$150,000.00	N/A	--
Provide three raft and boat access points on the Gunnison River.	$ 90,000.00	N/A	$ 3,000.00
Develop 25 campsites on the Gunnison River below Almont.	$325,000.00	N/A	$ 5,000.00
Develop 10 campsites and 18 miles of streamside trail on the East River between Almont and Crested Butte.	$2,350,000.00	N/A	$20,000.00
Develop 25 campsites on the Taylor River	$ 250,000.00	N/A	$ 5,000.00
Develop 30 RV campsites at Taylor Park	$ 210,000.00	N/A	$ 6,000.00
Develop 4 miles of streamside trail along Tomichi Creek though the City of Gunnison including a 3-acre park and 20 picnic sites.	$1,000,000.00	N/A	$ 9,000.00
Improve 32 existing primitive campsites along Cochetop Creek within Cochetopa Canyon.	$ 215,000.00	N/A	$ 6,500.00
Develop 17 miles of Uncompahgre River trail from Montrose to Ridgway Reservoir.	$1,700,000.00	N/A	$17,000.00

1 N/A denotes not applicable

12.0 STRUCTURAL COMPONENTS TO MEET IN-BASIN DEMANDS

12.1 INTRODUCTION

This chapter presents a discussion of the identification and screening of potential structural components. Specifically, the target objectives pertinent to this effort are:

1. Satisfy projected future municipal and industrial water demands within the study area.
2. Provide high quality recreation opportunities that will result in increased tourism and related economic benefits to the study area and to the State of Colorado.
3. Assure that an adequate water supply will be available to support the recreational opportunities proposed as a result of meeting Objective 2 above.
4. Satisfy projected future agricultural water demands in the study area.
5. Preserve the critical aspects of the environment such as water quality to the maximum practicable extent consistent with the other target objectives.

12.2 METHODOLOGY

Chapter 9 presented the comparison of existing water supplies with projected future water demands which is considered the No-Action Alternative. The No-Action Alternative modeling results identified the location and magnitude of future water shortages within the study area. The forecasted shortages are summarized as follows:

Municipal and Industrial Water Supply:

No shortage identified.

Irrigation Water Supply:

Tomichi Creek
Cochetopa Creek
Ohio Creek
Blue River
Happy Canyon Creek
Horsefly Creek
Upper Spring Creek

CWCB In-stream Flow Deficiencies:

Castle Creek
Cement Creek
Gunnison River
Cochetopa Creek
East River
Ohio Creek
Quartz Creek
Slate River
Soap Creek
Taylor River
Tomichi Creek

The shortages identified in the No-Action Alternative model results were used as the starting point to identify alternative structural components to meet projected in-basin demands. The components considered for this purpose consisted of storage reservoirs and transfer of water from one sub-basin to another by means of diversion structures and canals and/or pipelines.

An important assumption was made while identifying alternative structural components. That assumption is that any proposed storage reservoir must be multipurpose in nature. That is, a structural solution would not be proposed to serve one single purpose but should provide benefits for irrigation, recreation and, if possible, flood control.

Once alternative components were identified, a preliminary screening was carried out in order to eliminate components which failed to meet certain

critical criteria. Components which survived the preliminary screening were evaluated further. Preliminary operation studies were performed to size the component and then prefeasibility level project layouts and cost estimates were prepared for each. Finally, a comparative screening and ranking of components was carried out to recommend the most attractive alternative component to meet projected future shortages or deficiencies.

12.3 DEMAND AREAS

12.3.1 Agricultural Demands

12.3.1.1 Identification of Demands

Based on the agricultural demand forecast and the results of modeling the No-Action Alternative as disucssed in Chapters 8.0 and 9.0, respectively, eight sub-basins were shown to experience irrigation shortages using the hydrologic modeling period of 1952-1983. These sub-basins, associated irrigation shortages, and frequency of occurrence are presented in Table 12.1 while the locations of the shortages are shown on Figure 12.1. The average annual shortage presented in the table is the average of the years when shortages were experienced. In addition to the shortages shown in the table, the model also identified the Bostwick Park Project as experiencing a 420 af (1.3%) shortage to the average theoretical depletion requirement of 31,430 af during one irrigation season over the 32 year period of record. Due to the relatively small magnitude and infrequent occurrence of this shortage, it was not considered feasible to provide supplemental storage to meet this shortage.

TABLE 12.1

Identified Irrigation Shortages

Sub-basin	Number of Years w/ Shortage	Maximum Annual Shortage (af)	Average Annual Shortage (af)
Blue River	20	920	243
Cochetopa Creek	3	721	469
Cow Creek	3	756	394
Happy Canyon Creek	32	143	89
Horsefly Creek	32	118	53
Ohio Creek	5	1,831	793
Tomichi Creek	6	3,145	1,413
Upper Spring Creek	32	167	72

As discussed previously, the hydrologic model represents irrigation demands as depletions due to crop consumptive use requirements, not as diversions and return flows. Therefore, the irrigation shortages presented in Table 12.1 represent depletion shortages rather than diversion shortages.

A diversion shortage means that some water is physically available in the streams to meet crop requirements but the quantity available is insufficient to satisfy the crop requirement plus the delivery system losses. A depletion shortage, on the other hand, indicates that streamflow at the point of diversion is insufficient to meet the crop consumptive use requirement. Therefore, the shortages identified by the model depict the occurrence of a severe water shortage. In terms of providing a full irrigation water supply, the model understates the magnitude of the shortage by factor of up to four, i.e., diversion requirements can be up to four times depletion depending on the time of year. Also, the model underestimates the frequency of occurrence of shortages in terms of diversion requirements. The model therefore

identifies sub-basins with the most critical need for supplemental supplies of irrigation water supply and the sub-basins listed in Table 12.1 were considered as candidates for structural components to alleviate irrigation shortages.

12.3.1.2 Evaluation of Demand

The sub-basins that experience irrigation shortages most frequently are Happy Canyon Creek, Horsefly Creek and Upper Spring Creek. These creeks all are tributaries to the Uncompahgre River and the service area experiencing the shortage is high in the sub-basin and outside of the Uncompahgre Project boundary. The shortages, although frequent, affect less than 100 acres in each sub-basin. A cursory map study indicated that the areas could only be served by storage reservoirs located very high up in each sub-basin as a diversion canal from the Uncompahgre River is not feasible. Also, the hydrologic yield at the potential reservoir sites is low and would require a relatively large reservoir to carry over wet year storage in order to be effective. The study indicated that an expensive structure would be required to serve a very small service area in each case and it was not practical to consider satisfying the shortage in these sub-basins by means of structural components. Therefore, these three sub-basins were dropped from consideration as candidates for structural components to satisfy irrigation shortages.

The shortages predicted for the Blue River sub-basin were reviewed in detail because the predicted magnitude and frequency of occurrence of these shortages were not expected. Records of irrigated acreage in this sub-basin were poor to non-existent. In addition, the level of detail used in the model for this sub-basin is not as great as for the other sub-basins. Discussions with the Commissioner subsequent to the modeling revealed that severe shortages have not been reported historically and that recent purchase of relatively large tracts of ranch land have resulted in significant amounts of land being taken out of production. It was concluded that the shortages are probably overstated because the irrigated acreage originally used was too large. Furthermore, considering the lack of severe historical shortages and

the recent reduction of irrigated acreage as a result of land purchases, it was concluded that the Blue River sub-basin should not be considered as a candidate for a structural component to satisfy irrigation shortages.

Sub-basins remaining for evaluation of possible relief by means of in-basin structural components consist of: Ohio Creek, Cochetopa Creek, Tomichi Creek, and Cow Creek.

12.3.2 Municipal and Industrial Demands

No municipal and industrial (M&I) shortages were identified within the study area which would occur during the planning horizon of this study. Therefore, future M&I demands were not considered in developing structural plan components.

12.3.3 Recreation Demands

Providing structural components for the sole purpose of streamflow augmentation was identified as a low priority recreational/environmental enhancement component. Similarly, the need for increased flatwater recreation was identified as a low priority in the study area. This assignment of priority is based on public input obtained through interviews, questionnaires, and workshops conducted in the study area. However, streamflow augmentation demands and minimum recreation pools were considered to be desirable increments to multi-purpose water storage components. Structural components identified to meet other demands were therefore configured to provide recreation benefits also.

12.3.4 Water Quality

Water quality problems were identified on the Slate and East Rivers. Streamflow augmentation on the Slate and East Rivers below Crested Butte for the purpose of reducing ammonia concentrations caused by sewage treatment

plant effluent discharges during winter low flow/high population periods was also considered in developing structural plan components.

12.3.5 Flood Control

Spring runoff often causes flooding in the Gunnison and Uncompahgre Basins. In the spring of 1984, for example, serious flooding took place due to the rapid melt of heavy mountain snowpack which occurred during a period of very warm weather. Areas which were severely affected included Tomichi Creek, Quartz Creek, Cochetopa Creek, the East River, and the Gunnison River. Roads and bridges were washed out on many streams. Residences and structures were threatened on Tomichi Creek and on the Gunnison River above, below, and in the City of Gunnison. At the same time, flooding and severe channel bank erosion occurred on the Uncompahgre River above and below Montrose. Therefore, all potential storage reservoirs identified to meet other demands were also evaluated for the purpose of providing flood control benefits.

12.4 IDENTIFICATION OF ALTERNATIVE RESERVOIR SITES

As a first step in identifying potential storage sites, data related to previously proposed projects were reviewed. A total of 128 previously proposed sites within the study area were identified during the data collection phase of the study. Fifty-seven of these sites are located in the sub-basins with identified irrigation shortages and were considered as potential structural components for use in plan formulation.

Additionally, the Oh-Be-Joyful dam site on On-Be-Joyful Creek was identified from a previous study conducted by the City of Crested Butte. This site was analyzed as a potential solution to the high ammonia levels in the Slate River below Crested Butte.

In addition to a review of previously proposed storage sites, a topographic map search was conducted in all sub-basins with identified needs. Particular attention was focused on those sub-basins with no previously

identified sites; however, no new potential sites were identified by this effort.

12.5 PRELIMINARY SCREENING OF ALTERNATIVE RESERVOIR SITES

Figure 12.2 and Table 12.2 identify the 57 sites and their locations. These sites were subjected to a "critical factors" screening process to eliminate those with unacceptable attributes or those having no potential for meeting study objectives. The "critical factors" considered for elimination of potential sites included:

1. Sites located in sensitive environmental, cultural resource, and/or socially unacceptable areas (i.e. wilderness areas, inundation of extensive transportation corridors, inundation of large agricultural areas, etc.)
2. Sites located in areas of significant geologic hazards.
3. Sites with inadequate hydrologic potential to provide the required yield to satisfy irrigation shortages, water quality and/or streamflow enhancement objectives.
4. Position of site relative to lands with irrigation shortages.
5. Position of site relative to stream reaches with recreational, water quality, and/or environmental enhancement potential.

Table 12.2 also presents the results of the Critical Factor Screening.

TABLE 12.2

Alternative Storage Sites Considered

MAP ID NUMBER	NAME OF PROPOSED RESERVOIR	STREAM NAME	CRITICAL FACTOR(S) FAILED
COCHETOPA SUBBASIN			
54	Mc Donough	Los Pinos Creek	
71	Lower Los Pinos	Los Pinos Creek	
74	Upper Cochetopa	Cochetopa Creek	4
75	Banana Ranch	Cochetopa Creek	2
77	Lower Los Pinos	Los Pinos Creek	
84	Lower Cochetopa	Cochetopa Creek	1,4
104	Flying M	Los Pinos Creek	
123	Los Pinos #7	Los Pinos Creek	3
125	Pauline #1	Pauline Creek	
126	Pauline #2	Pauline Creek	
128	West Pass #1	Cochetopa Creek	4,5
COW CREEK SUBBASIN			
67	Ramshorn	Cow Creek	
69	Sneva	Dry Creek	4,5
109	Combs	Cow Creek	
EAST/SLATE RIVER			
34	Crested Butte (East)	East River	1,2,5
35	Slate-East	East River	1,5
37	Cement	Cement Creek	1,5
46	Farris (Lower)	Farris Creek	5
52	East	East River	5
88	Brush	Brush Creek	5
89	Farris (Upper)	Farris Creek	5
90	North Village Reservoir	East River	5
91	Meridian Lake	Washington Gulch	5
92	Rozman	Washington Gulch	5
93	Grant Lake	Slate River Trib.	3,5
129	Oh-Be-Joyful	Oh-Be-Joyful Creek	1,5
OHIO CREEK SUBBASIN			
15	Castle	Ohio Creek	2
16	Upper Willow Park	Castle Creek	1
47	Hinkle	Ohio Creek	2
55	Lower Willow Park	Castle Creek	1
120	Castleton	Castle Creek	
121	Castleton #2	Ohio Creek	2
122	Castleton #3	Ohio Creek	2

TABLE 12.2 (Continued)
Alternative Storage Sites Considered

TOMICHI CREEK SUBBASIN

13	Parlin	Tomichi Creek	1,4,5
18	Ohio City	Quartz Creek	4,5
32	Long Branch	Long Branch Creek	
41	Tomichi	Tomichi Creek	1,4,5
44	Pitkin	Quartz Creek	4,5
72	Sargents #1	Tomichi Creek	
73	Sargents (Sargents #3)	Tomichi Creek	
76	Sargents #2	Tomichi Creek	
78	Sargents #4	Tomichi Creek	
79	Upper Razor	Razor Creek	2,3,4,5
80	Lower Razor	Razor Creek	2,4,5
81	Needle	Needle Creek	3,4,5
82	Sargents #3	Tomichi Creek	
83	Crookton	Tomichi Creek	
85	Elko	Tomichi Creek	
100	Hartman Rock	Tomichi Creek	4,5
112	Ohio City #4	Quartz Creek	4,5
113	Ohio City #3	Quartz Creek	4,5
114	Ohio City #2	Quartz Creek	4,5
115	Ohio City #1	Quartz Creek	4,5
116	Monarch #5	Tomichi Creek	3
117	Monarch #4	Tomichi Creek	3
118	Monarch #3	Tomichi Creek	3
119	Monarch #2	Tomichi Creek	3

Potential storage sites surviving the "critical factors" screening were then investigated further. As an initial step in these investigations, the topography of the reservoir area was examined to determine if the site could provide the required storage capacity with a reasonably sized structure. Six sites were eliminated using this criteria: Long Branch and Crookton in the Tomichi sub-basin, Ramshorn and Combs in the Cow Creek sub-basin, and McDonough and Flying M in the Cochetopa sub-basin.

Additionally, the two identified Lower Los Pinos sites, Pauline #1 and #2, and Sargents and Sargents #3 were found to be minor variations of the same general site. In these cases the dam axis orientation providing the shortest dam length was selected for further study.

Preliminary reservoir operation studies and appraisal-level cost estimates were then conducted on the remaining sites. Table 12.3 presents a listing of these sites and their locations are shown on Figure 12.3.

TABLE 12.3

Alternative Storage Sites Retained For Further Study

MAP ID NUMBER	NAME OF PROPOSED RESERVOIR	STREAM NAME
COCHETOPA CREEK SUBBASIN		
77	Lower Los Pinos	Los Pinos Creek
126	Pauline	Pauline Creek
OHIO CREEK SUBBASIN		
120	Castleton	Castle Creek
TOMICHI CREEK SUBBASIN		
72	Sargents #1	Tomichi Creek
76	Sargents #2	Tomichi Creek
78	Sargents #4	Tomichi Creek
82	Sargents #3	Tomichi Creek
85	Elko	Tomichi Creek

12.6 PRELIMINARY RESERVOIR OPERATION STUDIES

Preliminary operation studies were conducted for the sites surviving the "critical factors" screening and topographic review to determine an initial reservoir sizing for each potential site. A 1952-57 hydrologic period of record was used for these preliminary modeling efforts since this period includes the most severe drought recorded in the 32-year period used in the basinwide model. The geographic extent of the models was limited to the sub-basin in which the potential storage facility is located. Irrigation demands and target streamflow enhancement demands were represented in the operation studies.

Reservoir capacities were selected to minimize spills and to satisfy demands to the extent possible. The capacities obtained were then used in preparing comparative cost estimates to further screen in-basin storage components.

12.7 CONVENTIONAL HYDROELECTRIC DEVELOPMENT

Each of the eight storage reservoirs evaluated was investigated to determine if the addition of an hydroelectric generating station would be economically feasible. It was assumed in each case that energy would be produced as a by-product when water was released for other purposes. The preliminary reservoir operation studies calculated the potential annual energy that could be produced at each storage site. The incremental cost of installing the hydro facilities was estimated and the value of the energy produced was calculated to derive an incremental benefit-cost ratio for each potential hydro facility.

The benefit-cost ratio for the two Upper Cochetopa sites was below 0.2; the Upper Ohio Creek site had a ratio of 0.35; and the ratios for the five Upper Tomichi sites ranged from 0.6 to 0.9. Since none of these sites appears to be suitable for a hydro evaluation and therefore will not affect the screening of alternative sites, the possibility of adding conventional hydro

facilities at in-basin storage facilities was dropped from further consideration during this study. If future phases of this study are carried out, this should be reevaluated when the choice of storage site and reservoir operating conditions are better defined.

12.8 COST ESTIMATING METHODS

A detailed description of the cost estimating methods used in this study is presented in Appendix F. This section presents a summary of the estimating methods that apply to structural components.

Cost estimates were prepared using a combination of three methodologies; Bureau of Reclamation reconnaissance level cost estimating programs, application of unit costs to estimated quantities, and lump sum construction costs of similar features from other projects. Quantity estimates and sizing parameters were obtained from preliminary engineering layouts prepared for each component considered. Miscellaneous items were estimated at 10 percent of the construction cost to account for minor items which were not specifically estimated on a selective basis where considered appropriate. All costs are expressed at January 1989 price levels.

The total capital cost includes the total estimated direct construction cost; contingencies; engineering and administrative expenses; and interest during construction. Contingencies were set at 25 percent of the construction costs before adding engineering and administrative expenses. The 25 percent contingency accounts for costs associated with; unforeseen geotechnical conditions, environmental mitigation, construction delays, and other factors that cannot be quantified during initial phases of project planning. As the project progresses to final design and more detailed information is obtained, the amount set aside for contingencies is usually reduced. Engineering and contract administrative costs (including administrative costs associated with obtaining environmental permits and licenses) were estimated to be 15 percent of the direct construction cost. Interest during construction was computed

based on an 8 percent interest rate with a linear drawdown of funds over the estimated construction period.

Total investment cost includes total capital cost, debt service reserve fund, and financing expenses. The debt service reserve fund was assumed to equal one year of debt service. Financing expenses were estimated to be approximately 3 percent of the total capital cost for projects less than or equal to $40 million and 1.5 percent of total capital cost for projects greater than $40 million.

Annual debt service costs are based on 30 year financing at an 8 percent interest rate. Annual operation and maintenance (O&M) costs were estimated using an empirical formula relating reservoir storage capacity to annual labor, equipment, and supply costs.

12.9 GENERAL DESCRIPTION OF SCREENED PROJECTS

A zoned earthfill embankment type dam was considered appropriate for each potential dam site. Figure 12.4 shows the typical embankment dam cross-section used. The following items are common to all the projects:

- The outlet works consist of an intake structure, outlet pipes through the dam with downstream control, and an energy dissipator. A multiple-level intake structure would be located in the reservoir to provide selective level reservoir releases. The hydraulic capacity of the outlet works was sized to provide approximately 400 percent of the maximum release requirement under normal operating conditions.

- Spillway sizing was based on safely passing the probable maximum flood (PMF). The spillway layout consists of an ungated side channel spillway. An ungated spillway was selected to assure safe unattended operation. The spillway crest was established to provide 10 feet of freeboard to the top of the embankment.

- Facilities for diversion of the river during construction utilize the outlet works pipe and were sized to accommodate the largest flood in the synthesized virgin flow record derived as described in Chapter 5.0.

- Project costs were estimated in accordance with the discussion presented in Appendix F and are expressed in January 1989 prices.

The following project descriptions summarize the eight water storage projects that were given further analysis beyond the preliminary screening process. These descriptions include physical descriptions of principal project features, site-specific geotechnical descriptions where available, and preliminary project cost estimates. The physical and geotechnical descriptions are based on a combination of visual site inspection, review of previous reports, and review of USGS 7-1/2 minute quad sheets.

12.10 LOS PINOS PROJECT

12.10.1 General

The Los Pinos dam site is located on Los Pinos Creek, 8.3 miles upstream of the confluence of Los Pinos and Cochetopa Creeks. Access to the site is provided by an existing two-lane gravel road. The dam layout and reservoir capacity data for the Los Pinos Project are presented in Figure 12.5.

12.10.2 Geotechnical

The reservoir basin is a wide, flat-bottomed pasture area that is geotechnically well-suited to the storage of water. The sides and bottom of the reservoir consist of granite and stream deposits, respectively. Numerous springs and swamp areas indicate a high tributary water table and gives indication that the reservoir basin would be watertight, providing that an adequate cutoff can be achieved beneath the dam.

Two types of rock are found on the abutments of the Los Pinos dam site. Granite occurs upstream and is overlain by andesite porphyry. The contact between these two formations is not exposed but dips downstream at about 10 degrees. Andesite is a hard, resistant, competent rock but contains many vertical columnar joints which may be difficult to seal. The granite is a medium-grained hard rock well-suited to dam construction. It contains surface contraction joints but should not prove difficult to seal by grouting.

Stream channel deposits cover the foundation rock to an estimated depth of 50 to 75 feet. These deposits are expected to be composed of permeable sands, gravels, and boulders therefore requiring a cutoff wall. Rock is fairly well exposed on both abutments but some removal of overburden will be required.

Alluvial fans located in the reservoir basin within 1 mile of the dam axis should provide ample construction materials for both the pervious and impervious zones of the embankment. Quarries in the granite or andesite porphyry are expected to provide riprap material of suitable quality. Concrete aggregate will probably have to be imported since the gravels along Cochetopa Creek are made up largely of volcanic ash and porphyry which are generally not acceptable for concrete aggregate.

12.10.3 Project Description and Cost

The crest length to dam height ratio of 8 to 1 at this site is favorable for the consideration of a zoned earthfill embankment dam. A zoned earthfill embankment dam was assumed due to the close proximity of the site to suitable construction materials. The dam at this site is 119 feet high and has a volume of 241,000 cubic yards (cy).

Construction of this facility will require the relocation of approximately 3 miles of two-lane gravel surfaced road. No other major relocations are expected to occur as a result of this project.

The total construction cost of the Los Pinos project was estimated at $12,627,000 which includes allowances for land acquisition and clearing; engineering, legal, and administration; and contingencies. The total investment cost of the project was estimated to be $16,099,000 which includes an allowance for interest during construction and financing expenses. The project features and the preliminary cost estimate are summarized in Table 12.4.

TABLE 12.4

Los Pinos Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservoir:	
Maximum Operating Water Surface (WS) Elevation	9,289 ft
Total Storage at Maximum WS Elevation	12,000 af
Active Storage at Maximum WS Elevation	10,800 af
Surface Area at Maximum WS Elevation	299 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	9,299 ft
Crest Length	800 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Secondary Gravel Road	2.8 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	307,000
Access Road	0
Land Acquisition	448,000
Diversion During Construction	307,000
Reservoir Clearing	420,000
Foundation Treatment	115,000
Dam Embankment	2,300,000
Spillway	2,592,000
Outlet Works	470,000
Instrumentation	46,000
Relocations	980,000
Miscellaneous Items (10%)	799,000
Subtotal Direct Cost	8,784,000
Contingencies (25%)	2,196,000
Total Direct Cost	10,980,000
Engineering, Legal, and Administration (15%)	1,647,000
Total Construction Cost	12,627,000
Interest During Construction (8% over 3 years)	1,573,000
Total Capital Cost	14,200,000
Debt Service Reserve Fund (1 year debt service)	1,430,000
Financing Expenses	469,000
Total Investment Cost	16,099,000
Annual Debt Service (8% over 30 years)	1,430,000
Annual O&M Cost	49,000
Total Annual Cost	1,479,000

12.11 PAULINE PROJECT

12.11.1 General

The Pauline dam site is located on Pauline Creek 4.2 miles upstream of the confluence of Pauline and Cochetopa Creeks. Access to the site would be provided by constructing 0.5 miles of two-lane gravel road. The dam layout and reservoir capacity data for the Pauline project are presented in Figure 12.6.

12.11.2 Geotechnical

The dam foundation area is covered with approximately 10 to 50 feet of alluvium overlying volcanic rocks. Bedrock exposures are not visible in the foundation area. The alluvium is composed of sand, gravel, and cobbles with some fine-grained material. There are also some boulders up to about 8 feet in size exposed in the alluvium.

Both abutments have silicic, volcanic rocks exposed. The lower portion of the left abutment and most of the right abutment are covered by talus. The volcanic rock is jointed but the joints appear relatively tight.

The most appropriate dam types would be zoned earthfill or rockfill embankments depending upon the amount of fine-grained material in the reservoir area. Material for drains might be processed from quarried rock, talus or soils in the reservoir area. Rockfill material could be obtained from the talus or valley alluvium. Aggregate may be available from processed talus or quarried volcanic rock at the site or it could be imported from Gunnison.

No significant geologic hazards were observed in the dam or reservoir areas.

12.11.3 Project Description and Cost

The crest length to dam height ratio of 11 to 1 at this site indicates the suitability for an embankment dam. A zoned earthfill embankment dam was assumed; however, more detailed site-specific study in a later phase may indicate the desirability of a rockfill or roller compacted concrete (RCC) type dam. The earthfill dam is 189 feet high and contains a volume of 640,000 cy.

Construction of this storage facility would require the relocation of 1.1 miles of two-lane gravel surfaced road. No other major relocations are expected to occur as a result of this project.

The total construction cost of the Pauline project was estimated at $19,497,000 and the total investment cost of the project was estimated to be $24,858,000. The project features and the preliminary cost estimate are summarized in Table 12.5.

TABLE 12.5

Pauline Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservior:	
Maximum Operating Water Surface (WS) Elevation	10,059 ft
Total Storage at Maximum WS Elevation	10,000 af
Active Storage at Maximum WS Elevation	9,000 af
Surface Area at Maximum WS Elevation	206 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	10,069 ft
Crest Length	2,100 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Secondary Gravel Road	1.1 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	474,000
Access Road	175,000
Land Acquisition	309,000
Diversion During Construction	428,000
Reservoir Clearing	360,000
Foundation Treatment	268,000
Dam Embankment	5,365,000
Spillway	3,744,000
Outlet Works	715,000
Instrumentation	107,000
Relocations	385,000
Miscellaneous Items (10%)	1,233,000
Subtotal Direct Cost	13,563,000
Contingencies (25%)	3,391,000
Total Direct Cost	16,954,000
Engineering, Legal, and Administration (15%)	2,543,000
Total Construction Cost	19,497,000
Interest During Construction (8% over 3 years)	2,429,000
Total Capital Cost	21,926,000
Debt Service Reserve Fund (1 year debt service)	2,208,000
Financing Expenses	724,000
Total Investment Cost	24,858,000
Annual Debt Service (8% over 30 years)	2,208,000
Annual O&M Cost	46,000
Total Annual Cost	2,254,000

12.12 CASTLETON PROJECT

12.12.1 General

The Castleton dam site is located on Castle Creek 2.7 miles upstream of the confluence of Castle and Ohio Creeks. Access to the site would be provided by constructing 2.8 miles of two-lane gravel road. The dam layout and reservoir capacity data for the Castleton Project are presented in Figure 12.7.

12.12.2 Geotechnical

Bedrocks in the vicinity of the dam site include crystalline granite overlain with sandstones and shales which are in turn overlain with several formations of volcanic ash and lava. Only the sedimentary and overlying volcanic rocks outcrop near the reservoir and dam site. The Mancos Shale which consists of a very thick series of dark-colored, thin-bedded shale outcrops over large areas in this vicinity. The depth of overburden was assumed to be approximately 50 feet at this site.

The reservoir basin is in an ancient glacial valley with broad flat-bottom and steep sides forming a classic U shape, well suited for a storage reservoir. Very fine glacial moraines make up both the sides and bottom of this basin, and numerous springs and swampy areas indicate a high tributary ground water table. These conditions indicate a tight impervious basin which will probably store water without appreciable seepage losses.

Both abutments and the foundation are in glacial moraines. This material is very fine since the source of the material was clays and weathered shales. Some boulders exist in this material but form only a small percentage of the material in the area. The most questionable feature of this site is its stability. Existing slopes along the canyon walls are very steep. These slopes appear to have stood without slumping to any noticeable degree.

However, under fluctuating reservoir operation this material may tend to slump.

Glacial moraines would provide an abundance of impervious material. No gravel deposits were observed in the area. Concrete aggregate and riprap materials may need to be imported to the site. Pervious embankment materials would likely be imported from the Ohio Creek area.

12.12.3 Project Description and Cost

The crest length to dam height ratio of 7 to 1 at this site is favorable for the consideration of an embankment dam. A zoned earthfill embankment dam was assumed due to the close proximity of the site to suitable construction materials. The dam is 199 feet high and has a volume of 599,000 cy.

Construction of this storage facility will not require the relocation of any major features.

The total construction cost of the Castleton project was estimated at $20,900,000 and the total investment cost of the project was estimated to be $26,647,000. The project features and preliminary cost estimate is summarized in Table 12.6.

TABLE 12.6

Castleton Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservior:	
Maximum Operating Water Surface (WS) Elevation	9,389 ft
Total Storage at Maximum WS Elevation	20,000 af
Active Storage at Maximum WS Elevation	18,000 af
Surface Area at Maximum WS Elevation	286 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	9,389 ft
Crest Length	1,550 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
none	

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	508,000
Access Road	980,000
Land Acquisition	429,000
Diversion During Construction	338,000
Reservoir Clearing	540,000
Foundation Treatment	261,000
Dam Embankment	5,228,000
Spillway	3,598,000
Outlet Works	1,230,000
Instrumentation	105,000
Relocations	0
Miscellaneous Items (10%)	1,322,000
Subtotal Direct Cost	14,539,000
Contingencies (25%)	3,635,000
Total Direct Cost	18,174,000
Engineering, Legal, and Administration (15%)	2,726,000
Total Construction Cost	20,900,000
Interest During Construction (8% over 3 years)	2,604,000
Total Capital Cost	23,504,000
Debt Service Reserve Fund (1 year debt service)	2,367,000
Financing Expenses	776,000
Total Investment Cost	26,647,000
Annual Debt Service (8% over 30 years)	2,367,000
Annual O&M Cost	59,000
Total Annual Cost	2,426,000

12.13 ELKO PROJECT

12.13.1 General

The Elko dam site is located on Tomichi Creek, 26 miles east of Gunnison. Access to the site is provided via Highway 50. The dam layout and reservoir capacity data for the Elko Project are presented in Figure 12.8.

12.13.2 Geotechnical

The proposed dam and reservoir site is situated on the southwestern edge of the Sawatch Range. The sedimentary rocks in the area range from Jurassic to late Cretaceous in age and are nearly horizontal with a dip of about 8 degrees to the west. The Crookton fault, which is about 2 miles downstream of the dam site, strikes north 30 to 35 degrees east. Glacial deposits are found in the Tomichi Creek valley in the form of moraines and glacial outwash. However, much of this material has been reworked and is now seen as stream channel deposits. The canyon along Tomichi Creek is bordered by several small to medium-sized alluvial fans which were deposited by intermittent tributaries to Tomichi Creek. The depth of overburden at this site was assumed to be 50 feet.

The dam site is located in a broad flat-bottomed canyon. Several alluvial fans that border the proposed reservoir have been identified for pervious and possibly impervious borrow material. Large quantities of impervious material have been identified 3 miles downstream from the dam axis. The sand and gravel in the canyon bottom may be a potential source of concrete aggregate but preliminary indications are that they may prove to be unsuitable for that purpose. Aggregate materials may need to be imported if the local material proves to be unsuitable. The most apparent source of riprap would be to quarry the granite outcrops located 4 miles upstream of the dam axis.

12.13.3 Project Description and Cost

The crest length to dam height ratio of 12 to 1 at this site indicates the suitability for an embankment dam. A zoned earthfill embankment dam was assumed due to the relatively close proximity of the site to suitable construction materials. The dam is 121 feet high and has a volume of 492,000 cy.

Construction of this storage facility would require the relocation of Highway 50. Approximately four miles of newly constructed two-lane highway would be required to bypass the dam and reservoir area. The alignment of this road relocation is presented in Figure 12.8. No other major features would require relocation.

The total construction cost of the Elko Project was estimated at $22,494,000 and the total investment cost of the project was estimated to be $28,678,000. The project features and preliminary cost estimate are summarized in Table 12.7.

TABLE 12.7

Elko Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservoir:	
Maximum Operating Water Surface (WS) Elevation	8,381 ft
Total Storage at Maximum WS Elevation	30,000 af
Active Storage at Maximum WS Elevation	27,000 af
Surface Area at Maximum WS Elevation	540 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	8,391 ft
Crest Length	1,350 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Highway 50	3.6 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	547,000
Access Road	0
Land Acquisition	810,000
Diversion During Construction	501,000
Reservoir Clearing	200,000
Foundation Treatment	223,000
Dam Embankment	4,455,000
Spillway	3,074,000
Outlet Works	726,000
Instrumentation	89,000
Relocations	3,600,000
Miscellaneous Items (10%)	1,423,000
Subtotal Direct Cost	15,648,000
Contingencies (25%)	3,912,000
Total Direct Cost	19,560,000
Engineering, Legal, and Administration (15%)	2,934,000
Total Construction Cost	22,494,000
Interest During Construction (8% over 3 years)	2,802,000
Total Capital Cost	25,296,000
Debt Service Reserve Fund (1 year debt service)	2,547,000
Financing Expenses	835,000
Total Investment Cost	28,678,000
Annual Debt Service (8% over 30 years)	2,547,000
Annual O&M Cost	68,000
Total Annual Cost	2,615,000

12.14 SARGENTS No. 1 PROJECT

12.14.1 General

The Sargents No. 1 dam site is located on Tomichi Creek, 28.3 miles east of Gunnison or approximately 2.3 miles upstream of the Elko dam site. Access to the site is provided via Highway 50. The dam layout and reservoir capacity data for the Sargents No. 1 Project are presented in Figure 12.9.

12.14.2 Geotechnical

No site specific geologic information from previous reports is available for this site; however visual inspection indicates geologic conditions are very similar to the Elko Project site.

12.14.3 Project Description and Cost

The crest length to dam height ratio of 7 to 1 at this site is favorable for consideration of an embankment dam. A zoned earthfill embankment dam was assumed due to the relatively close proximity of the site to suitable construction materials. The dam is 144 feet high and has a volume of 386,000 cy.

Construction of this storage facility will require the relocation of the Town of Sargents, Highway 50, and a secondary gravel road. Approximately four miles of newly constructed two-lane highway and 2.5 miles of two-lane gravel road will be required to bypass the dam and reservoir area. The alignment of these road relocations are presented on Figure 12.9. The total construction cost of the Sargents No. 1 Project was estimated at $26,465,000 and the total investment cost of the project was estimated to be $33,742,000. The project features and preliminary cost estimate are summarized in Table 12.8.

TABLE 12.8

Sargents No. 1 Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservoir:	
Maximum Operating Water Surface (WS) Elevation	8,489 ft
Total Storage at Maximum WS Elevation	30,000 af
Active Storage at Maximum WS Elevation	27,000 af
Surface Area at Maximum WS Elevation	661 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	8,499 ft
Crest Length	910 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Highway 50	2.9 mi
Secondary Gravel Road	1.5 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	644,000
Access Road	0
Land Acquisition	992,000
Diversion During Construction	398,000
Reservoir Clearing	200,000
Foundation Treatment	178,000
Dam Embankment	3,563,000
Spillway	3,794,000
Outlet Works	821,000
Instrumentation	71,000
Relocations	6,075,000
Miscellaneous Items (10%)	1,674,000
Subtotal Direct Cost	18,410,000
Contingencies (25%)	4,603,000
Total Direct Cost	23,013,000
Engineering, Legal, and Administration (15%)	3,452,000
Total Construction Cost	26,465,000
Interest During Construction (8% over 3 years)	3,297,000
Total Capital Cost	29,762,000
Debt Service Reserve Fund (1 year debt service)	2,997,000
Financing Expenses	983,000
Total Investment Cost	33,742,000
Annual Debt Service (8% over 30 years)	2,997,000
Annual O&M Cost	68,000
Total Annual Cost	3,065,000

12.15 SARGENTS No. 2 PROJECT

12.15.1 General

The Sargents No. 2 dam site is located on Tomichi Creek 28.9 miles east of Gunnison or approximately 2.9 miles upstream of the Elko dam site. Access to the site is provided via Highway 50. The dam layout and reservoir capacity data for the Sargents No. 2 Project are presented in Figure 12.10.

12.15.2 Geotechnical

No site specific geologic information from previous reports is available for this site; however visual inspection indicates geologic conditions are very similar to the Elko Project site.

12.15.3 Project Description and Cost

The crest length to dam height ratio of 7 to 1 at this site is favorable for consideration of an embankment dam. A zoned earthfill embankment dam was assumed due to the relatively close proximity of the site to suitable construction materials. The dam is 139 feet high and has a volume of 260,000 cy.

Construction of this storage facility would require the relocation of the Town of Sargents, Highway 50, and a secondary gravel road. Approximately four miles of newly constructed two-lane highway and 2.5 miles of two-lane gravel road will be required to bypass the dam and reservoir area. The alignment of these road relocations are presented on Figure 12.10. No other major features would require relocation. The total construction cost of the Sargents No. 2 Project was estimated at $23,754,000 and the total investment cost of the project was estimated to be $30,285,000. The project features and preliminary cost estimate are summarized in Table 12.9.

TABLE 12.9

Sargents No. 2 Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservoir:	
Maximum Operating Water Surface (WS) Elevation	8,494 ft
Total Storage at Maximum WS Elevation	30,000 af
Active Storage at Maximum WS Elevation	27,000 af
Surface Area at Maximum WS Elevation	674 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	8,504 ft
Crest Length	850 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Highway 50	4.2 mi
Secondary Gravel Road	2.5 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	578,000
Access Road	0
Land Acquisition	1,011,000
Diversion During Construction	379,000
Reservoir Clearing	160,000
Foundation Treatment	121,000
Dam Embankment	2,428,000
Spillway	3,485,000
Outlet Works	737,000
Instrumentation	49,000
Relocations	6,075,000
Miscellaneous Items (10%)	1,502,000
Subtotal Direct Cost	16,525,000
Contingencies (25%)	4,131,000
Total Direct Cost	20,656,000
Engineering, Legal, and Administration (15%)	3,098,000
Total Construction Cost	23,754,000
Interest During Construction (8% over 3 years)	2,959,000
Total Capital Cost	26,713,000
Debt Service Reserve Fund (1 year debt service)	2,690,000
Financing Expenses	882,000
Total Investment Cost	30,285,000
Annual Debt Service (8% over 30 years)	2,690,000
Annual O&M Cost	68,000
Total Annual Cost	2,758,000

12.16 SARGENTS No. 3 PROJECT

12.16.1 General

The Sargents No. 3 dam site is located on Tomichi Creek, 31.3 miles east of Gunnison or approximately 5.3 miles upstream of the Elko dam site. Access to the site is provided via Highway 50. The dam layout and reservoir capacity data for the Sargents No. 3 Project are presented on Figure 12.11.

12.16.2 Geotechnical

No site-specific geologic information from previous reports is available for this site; however visual inspection indicates geologic conditions are very similar to the Elko Project site.

12.16.3 Project Description and Cost

The crest length to dam height ratio of 15 to 1 at this site indicates that an embankment dam would be most suitable. A zoned earthfill embankment dam was assumed due to the relatively close proximity of the site to suitable construction materials. The dam is 143 feet high and has a volume of 771,000 cy.

Construction of this storage facility will require the relocation of Highway 50 and a secondary gravel road. To bypass the dam and reservoir area approximately three miles of newly constructed two-lane highway and 1.5 miles of two-lane gravel road would be required. The alignment of these road relocations are presented in Figure 12.11. No other major features would require relocation. The total construction cost of the Sargents No. 3 Project was estimated at $25,936,000 and the total investment cost of the project was estimated to be $33,067,000. The project features and preliminary cost estimate are summarized in Table 12.10.

TABLE 12.10

Sargents No. 3 Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservoir:	
Maximum Operating Water Surface (WS) Elevation	8,593 ft
Total Storage at Maximum WS Elevation	25,000 af
Active Storage at Maximum WS Elevation	22,500 af
Surface Area at Maximum WS Elevation	474 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	8,603 ft
Crest Length	2,000 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Highway 50	2.9 mi
Secondary Gravel Road	1.5 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	631,000
Access Road	0
Land Acquisition	711,000
Diversion During Construction	541,000
Reservoir Clearing	150,000
Foundation Treatment	334,000
Dam Embankment	6,689,000
Spillway	2,966,000
Outlet Works	821,000
Instrumentation	134,000
Relocations	3,425,000
Miscellaneous Items (10%)	1,640,000
Subtotal Direct Cost	18,042,000
Contingencies (25%)	4,511,000
Total Direct Cost	22,553,000
Engineering, Legal, and Administration (15%)	3,383,000
Total Construction Cost	25,936,000
Interest During Construction (8% over 3 years)	3,231,000
Total Capital Cost	29,167,000
Debt Service Reserve Fund (1 year debt service)	2,937,000
Financing Expenses	963,000
Total Investment Cost	33,067,000
Annual Debt Service (8% over 30 years)	2,937,000
Annual O&M Cost	63,000
Total Annual Cost	3,000,000

12.17 SARGENTS No. 4 PROJECT

12.17.1 General

The Sargents No. 4 dam site is located on Tomichi Creek, 30 miles east of Gunnison or approximately 4 miles upstream of the Elko dam site. Access to the site is provided via Highway 50. The dam layout and reservoir capacity data for the Sargents No. 4 Project are presented in Figure 12.12.

12.17.2 Geotechnical

No site-specific geologic information from previous reports is available for this site; however visual inspection indicates geologic conditions are very similar to the Elko Project site.

12.17.3 Project Description and Cost

The crest length to dam height ratio of 12 to 1 at this site indicates that an embankment dam would be most suitable. A zoned earthfill embankment dam was assumed due to the relatively close proximity of the site to suitable construction materials. The dam is 108 feet high and has a volume of 347,000 cy.

Construction of this storage facility will require the relocation of the Town of Sargents, Highway 50, and a secondary gravel road. Approximately four miles of newly constructed two-lane highway and 3.7 miles of two-lane gravel road would be required to bypass the dam and reservoir area. The alignment of these road relocations are presented in Figure 12.12. The total construction cost of the Sargents No. 4 Project was estimated at $22,868,000 and the total investment cost of the project was estimated to be $29,156,000. The project features and preliminary cost estimate are summarized in Table 12.11.

TABLE 12.11

Sargents No. 4 Project
Project Description and Cost Estimate

PROJECT DESCRIPTION

Reservoir:	
Maximum Operating Water Surface (WS) Elevation	8,518 ft
Total Storage at Maximum WS Elevation	25,000 af
Active Storage at Maximum WS Elevation	22,500 af
Surface Area at Maximum WS Elevation	578 ac
Dam:	
Type	Earthfill Embankment
Crest Elevation	8,528 ft
Crest Length	1,200 ft
Spillway	Ungated Side Channel
Outlet Works	Multi-Level
Relocation:	
Highway 50	3.7 mi
Secondary Gravel Road	3.7 mi

PROJECT COST ESTIMATE

Project Features	--- COST ---
Mobilization	556,000
Access Road	0
Land Acquisition	867,000
Diversion During Construction	433,000
Reservoir Clearing	160,000
Foundation Treatment	160,000
Dam Embankment	3,197,000
Spillway	2,419,000
Outlet Works	611,000
Instrumentation	64,000
Relocations	5,995,000
Miscellaneous Items (10%)	1,446,000
Subtotal Direct Cost	15,908,000
Contingencies (25%)	3,977,000
Total Direct Cost	19,885,000
Engineering, Legal, and Administration (15%)	2,983,000
Total Construction Cost	22,868,000
Interest During Construction (8% over 3 years)	2,849,000
Total Capital Cost	25,717,000
Debt Service Reserve Fund (1 year debt service)	2,590,000
Financing Expenses	849,000
Total Investment Cost	29,156,000
Annual Debt Service (8% over 30 years)	2,590,000
Annual O&M Cost	63,000
Total Annual Cost	2,653,000

12.18 WATER IMPORTS FROM OTHER GUNNISON RIVER SUB-BASINS

As an alternative to providing storage reservoirs to meet irrigation shortages, the possibility of importing water from adjacent sub-basins via canal and/or pipeline was investigated. The possibilities considered were: diverting water from the Gunnison River to Ohio Creek, and diverting water from Tomichi Creek to Cochetopa Creek. The first was discarded because a canal that would serve the majority of the Ohio Creek service area experiencing shortages would be very long and costly. A Tomichi Creek to Cochetopa Creek transport component was evaluated at a pre-feasibility level.

The canal sizing was based on the peak monthly irrigation release identified by the preliminary Los Pinos reservoir operation study thereby providing an equal level of benefits between the alternative water transfer and storage components. This criteria resulted in a 27 cfs canal capacity. Assuming a trapezoidal canal cross-section with 2:1 side slopes and 6 ft bottom width, the identified capacity requires a 0.0007 canal slope.

The canal alignment was determined by back tracking from an assumed delivery point on Cochetopa Creek at the 9,000 ft contour. This delivery point would accommodate diversions from Cochetopa Creek to the existing Smith Ford and Perry ditches which provide service to the majority of irrigated lands in the Cochetopa basin. Using the assumed delivery point and the 0.0007 slope requirement resulted in a 208,800 ft canal length with 150 ft elevation rise to reach Long Branch Creek, the nearest major Tomichi Creek tributary. Siphons ranging from 20 to 490 ft of static head were required for stream crossings and totaled 57,800 ft in length.

The construction cost estimate for the canal sections only (excluding siphon and diversion dam) is $10,602,000 as compared to an $12,627,000 construction cost for the Los Pinos dam and reservoir with a 12,000 af capacity. Therefore this concept was dropped from further consideration on the basis of economic considerations.

12.19 SCREENING OF ALTERNATIVES

12.19.1 Screening Criteria

Structural plan components were screened on the basis of their ability to meet the target objectives stated at the beginning of this chapter. Screening of the structural components described in the previous section consisted of a comparative evaluation to eliminate non-competitive components and to rank the remaining components. The comparative screening criteria includes the following categories: technical, environmental, institutional/social and economic. The orientation of the criteria is to evaluate the following characteristics of a proposed component:

- o Degree to which target objectives are met
- o Efficiency as measured by economic factors
- o Environmental impacts
- o Institutional/social constraints
- o Cost

Table 12.12 presents a summary of the results of this alternative screening process. Individual screening sheets for each component are presented in Appendix G.

12.19.2 Cochetopa Creek Basin

An inspection of the results of Table 12.12 for the Los Pinos and Pauline sites indicates that both are ranked equally for all factors with the exception of Target Objective No. 4 and level of difficulty associated with establishing water rights.

Due to its position in Cochetopa Basin, the Los Pinos site is unable to provide an irrigation supply to irrigated lands above the confluence of Los Pinos and Cochetopa Creeks due to the physical unavailability of water in Cochetopa Creek in some years. This condition precludes the possibility of

meeting Target Objective No. 4, even with a water rights exchange. The Pauline site can meet Target Objective No. 4 by providing an irrigation supply to all currently irrigated lands in the Cochetopa Basin.

Conditional water rights in the amount of 15,457 af with a priority date of 1957, associated with the Los Pinos site, are held by the Upper Gunnison Water Conservancy District. The Pauline site has no conditional water rights but the District has two decrees on the Upper Cochetopa which could possibly be transferred to the Pauline site.

The Pauline site satisfies the target objective to a greater degree; however, due to the significant cost per unit storage difference ($1,342/af for Los Pinos and $2,486/af for Pauline) and their relative environmental effects, both sites should be retained for more site specific investigation in a later phase of study.

12.19.3 Ohio Creek Basin

Since the preliminary critical factors screening process eliminated all other alternative Ohio Creek storage sites, and the Castleton site meets the identified shortages in the basin with a reasonable degree of cost effectiveness in an environmentally sound manner, it is recommended for further consideration in a subsequent phase of study.

12.19.4 Tomichi Creek Basin

An inspection of Table 12.12 indicates that all five sites are ranked equally for all factors with the exception of Hydrologic Reliability and Public Acceptance.

Due to its relatively high position in the basin the Sargents No. 3 site is the only storage facility that can provide an irrigation supply to all currently irrigated lands. With its relatively low position in the basin the Elko site has a higher degree of hydrologic reliability due to its larger

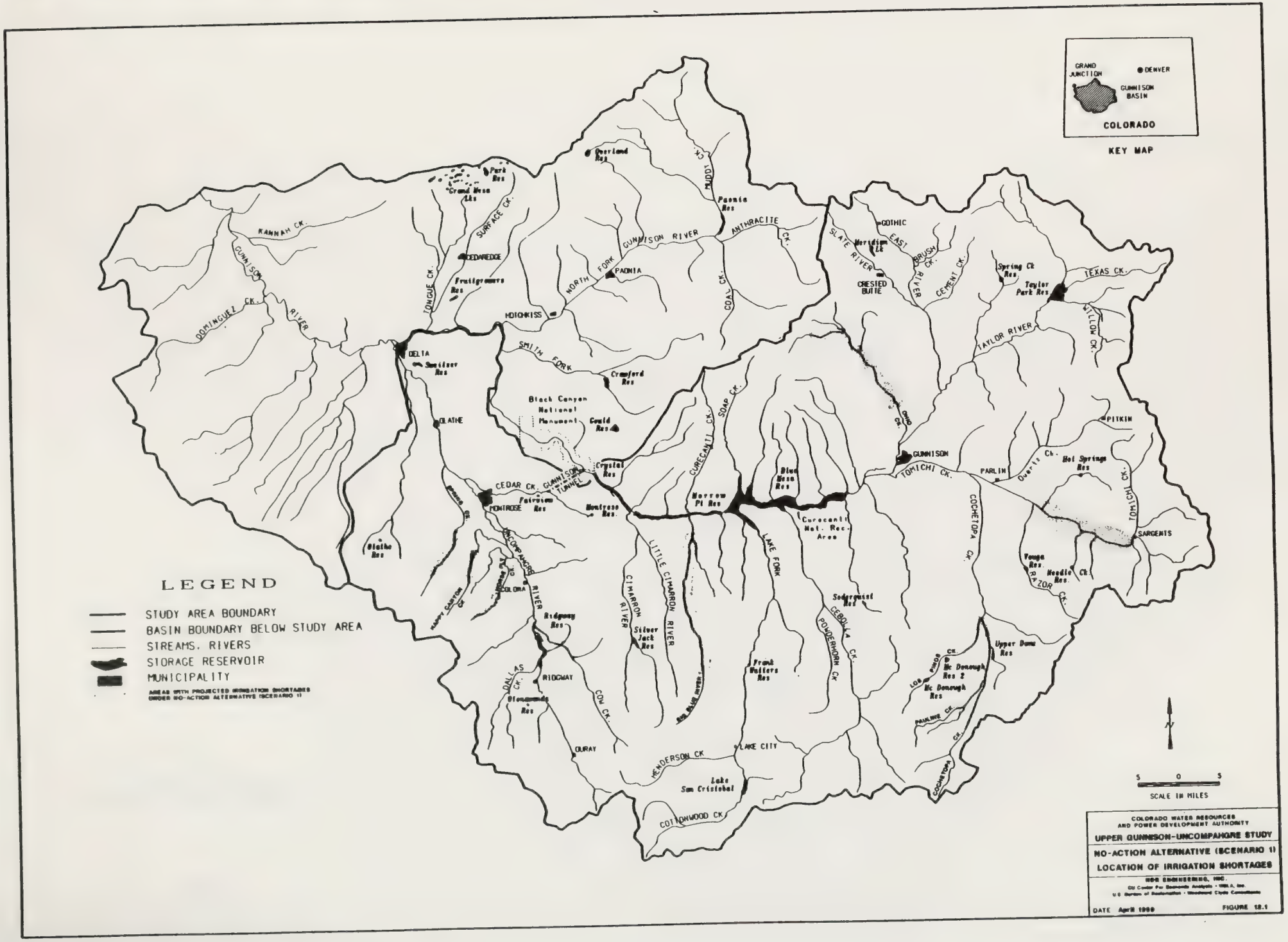
inflow drainage area as compared to the other four sites. Elko and Sargents No. 3 do not inundate the Town of Sargents as is the case with the remaining three sites and are therefore rated higher with respect to public acceptance.

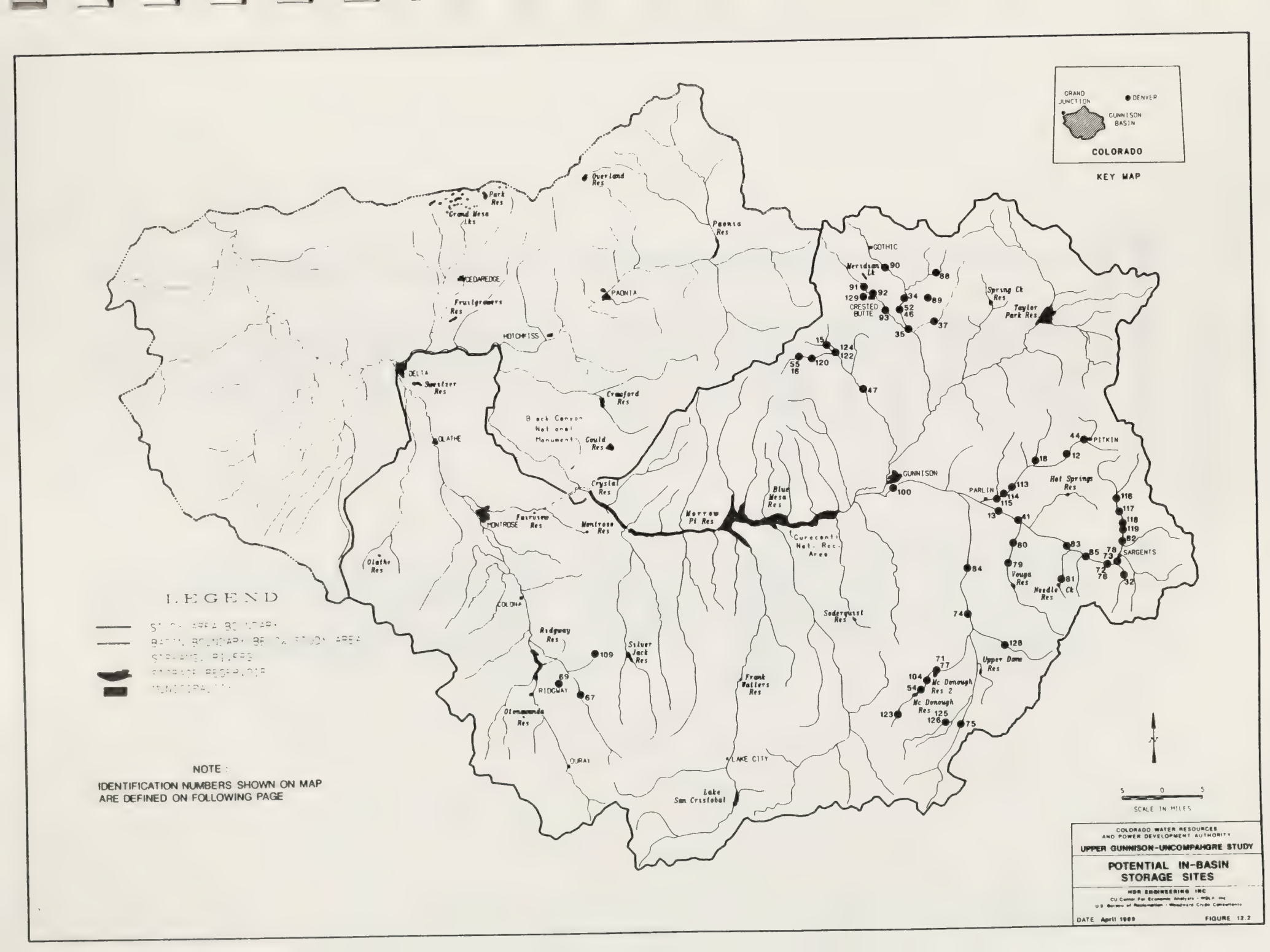
Based on non-economic factors, the Sargents No. 3 site is slightly more attractive, primarily because it can meet irrigation shortages to a greater degree than the other sites. The Elko site on the other hand is slightly better from the recreational standpoint, both ability to provide enhanced streamflow and flatwater recreation, and from the standpoint of providing flood control. The Elko site is also preferable from the standpoint of cost. Therefore, it is recommended that both of these sites be considered during the plan formulation and evaluation phase of this study. Both sites should also be studied further in future phases of this study to confirm which site is the superior location for a storage reservoir.

TABLE 12.12

Summary of Screening

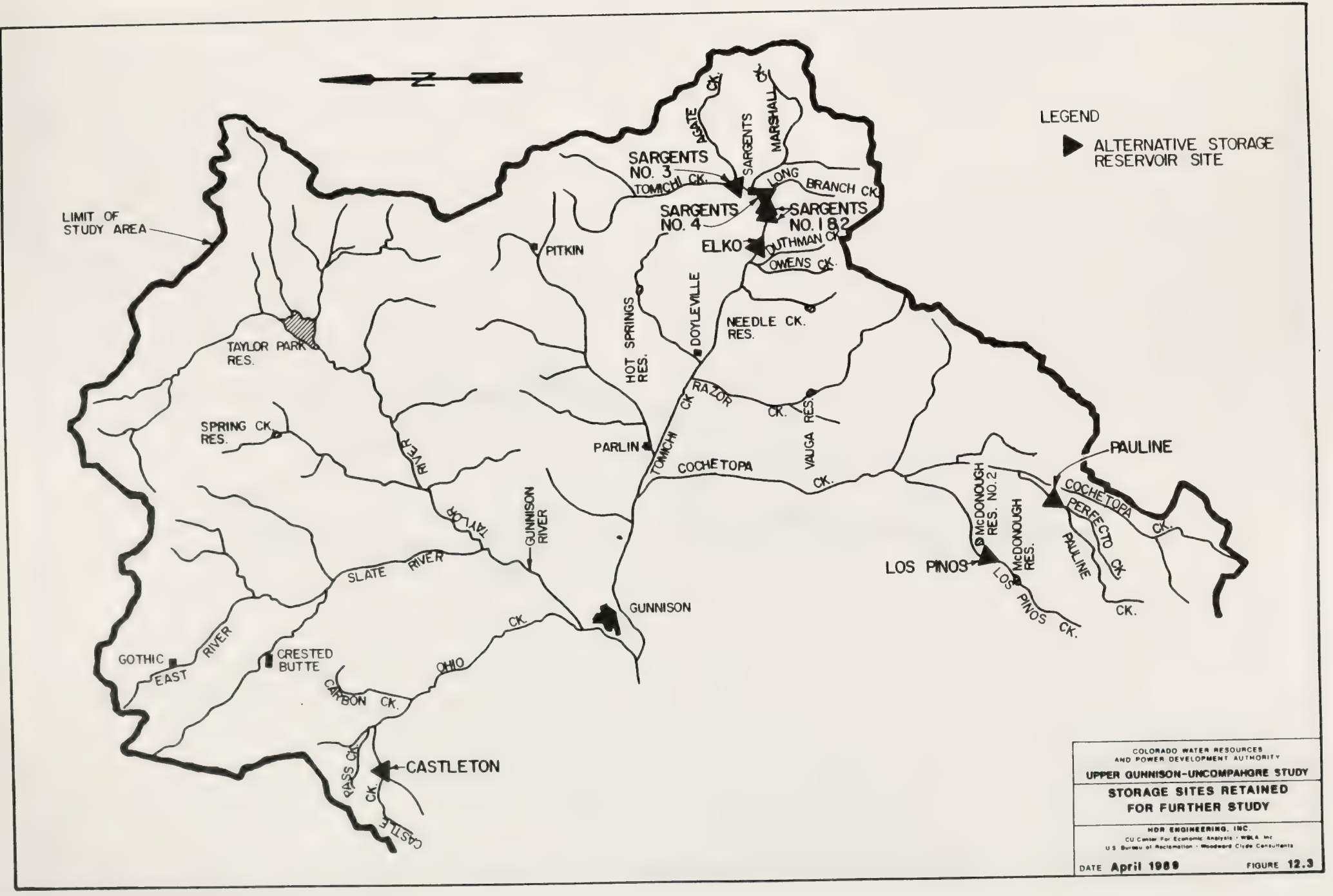
SCREENING FACTOR	COCHETOPA CREEK		OHIO CREEK	TOMICHI CREEK				
	LOS PINOS	PAULINE	CASTLETON	ELKO	SARGENTS 1	SARGENTS 2	SARGENTS 3	SARGENTS 4
Provides Stream Flow Enhancement (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provides Full Irrigation Supply to Currently Irrigated Lands (Yes/No)	No	Yes	Yes	No	No	No	Yes	No
Geologic and Cost Risk Assessment (Low/Moderate/High)	Low	Low	Low	Low	Low	Low	Low	Low
Hydrologic/Functional Reliability (Low/Moderate/High)	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate	Moderate
Potential Impact to Wildlife (Beneficial/Neutral/Detrimental)	Neutral	Neutral	Neutral	Detrimental	Detrimental	Detrimental	Detrimental	Detrimental
Potential Impact to Fishery (Beneficial/Neutral/Detrimental)	Neutral	Neutral	Neutral	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Potential Impact to Vegetation (Beneficial/Neutral/Detrimental)	Neutral	Neutral	Detrimental	Neutral	Neutral	Neutral	Neutral	Neutral
Potential Impact to Cultural Resources (Beneficial/Neutral/Detrimental)	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Potential Impact to Recreational and Aesthetic Values (Beneficial/Neutral/Detrimental)	Beneficial	Beneficial	Neutral	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Potential Impact to Water Quality (Beneficial/Neutral/Detrimental)	Neutral	Neutral	Neutral	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Potential for Public Opposition (Low/Moderate/High)	Moderate	Moderate	Moderate	Moderate	High	High	Moderate	High
Potential for Land Use Conflict (Low/Moderate/High)	Moderate	Moderate	Moderate	Moderate	High	High	Moderate	High
Potential for Land Acquisition Problems (Low/Moderate/High)	Low	Low	Low	Moderate	High	High	Moderate	High
Potential for Water Right Acquisition Problems (Low/Moderate/High)	Low	Moderate	Low	Low	Low	Low	Low	Low
Total Investment Cost (X1000)	$16,099	$24,858	$26,647	$28,678	$33,742	$30,285	$33,067	$29,156
Annual Cost of Storage ($ per acre-foot per year)	1,342	2,486	1,332	956	1,125	1,010	1,323	1,166


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
LEGEND
STUDY AREA BOUNDARY
BASIN BOUNDARY BELOW STUDY AREA
STREAMS, RIVERS
STORAGE RESERVOIR
MUNICIPALITY
AREAS WITH PROJECTED IRRIGATION SHORTAGES UNDER NO-ACTION ALTERNATIVE (SCENARIO 1)
GUNNISON RIVER
NORTH FORK
SURFACE CK.
KANNAH CK.
DOMINGUEZ CK.
JONQUE CK.
CEDAREDGE
Fruitgrowers Res
Grand Mesa Lks
Overland Res
Paonia Res
PAONIA
HOTCHKISS
DELTA
Surface Res
OLATHE
SMITH FORK
Crawford Res
Black Canyon National Monument
Gould Res
Crystal Res
CEDAR CK.
GUNNISON TUNNEL
MONTROSE
Fairview Res
Montrose Res
Blaine Res
Happy Canyon Ck
Uncompahgre River
COLONA
Ridgway Res
DALLAS CK.
RIDGWAY
Ironjacket Res
COW CK.
OURAY
HENDERSON CK
Lake San Cristobal
COTTONWOOD CK
LAKE CITY
CIMARRON RIVER
Silver Jack Res
LITTLE CIMARRON RIVER
Morrow Pt Res
CURECANTI CK.
SOAP CK.
Curecanti Nat. Rec. Area
Blue Mesa Res
LAKE FORK
Soapstone Res
Frank Waters Res
POWDERHORN CK
CEBOLLA CK
COCKTOPA CK
ANTHRACITE CK.
COAL CK.
MUDDY CK.
GOTHIC
Meridian Lk
EAST RIVER
SLATE RIVER
CRESTED BUTTE
BRUSH CK.
CEMENT CK.
Spring Ck Res
Taylor Park Res
TEXAS CK.
WILLOW CK.
TAYLOR RIVER
OHIO CK.
GUNNISON
TOMICHI CK.
PARLIN
Quartz Ck.
Hot Springs Res
PITKIN
TOMICHI CK.
SARGENTS
Youga Res.
Needle Ck.
RAZOR CK.
Upper Dome Res
LOG CHUTE CK
McDonough Res 2
McDonough Res
DOLORES CK.
SCALE IN MILES
5 0 5
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
NO-ACTION ALTERNATIVE (SCENARIO 1)
LOCATION OF IRRIGATION SHORTAGES
DATE April 1980
FIGURE 12.1


GRAND JUNCTION
DENVER
GUNNISON BASIN
COLORADO
KEY MAP
Park Res
Grand Mesa Lks
Overland Res
Paonia Res
CEDAREDGE
Fruitgrowers Res
PAONIA
HOTCHKISS
DELTA
Surface Res
OLATHE
Crawford Res
Black Canyon National Monument
Gould Res
Crystal Res
MONTROSE
Fairview Res
Montrose Res
Olathe Res
COLONA
Ridgway Res
Silver Jack Res
RIDGWAY
Ohamanda Res
OURAY
LAKE CITY
Lake San Cristobal
Morrow Pt Res
Blue Mesa Res
Curecanti Nat. Rec. Area
Soderquist Res
Front Walters Res
GOTHIC
Meridian Lk
CRESTED BUTTE
Spring Ck Res
Taylor Park Res
GUNNISON
PARLIN
Hot Springs Res
PITKIN
SARGENTS
Vouga Res
Needle Ck
Upper Dome Res
Mc Donough Res 2
Mc Donough Res
LEGEND
STUDY AREA BOUNDARY
BASIN BOUNDARY BEYOND STUDY AREA
STREAMS, RIVERS
RESERVOIR REGION
MUNICIPAL
NOTE :
IDENTIFICATION NUMBERS SHOWN ON MAP
ARE DEFINED ON FOLLOWING PAGE
N
5 0 5
SCALE IN MILES
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
POTENTIAL IN-BASIN STORAGE SITES
HDR ENGINEERING INC
DATE April 1980
FIGURE 12.2

Alternative Storage Sites Considered
(Index to Figure 12.2)

MAP ID NUMBER	PROPOSED RESERVOIR	STREAM NAME
Cochetopa Subbasin		
54	McDonough	Los Pinos Creek
71	Lower Los Pinos	Los Pinos Creek
74	Upper Cochetopa	Cochetopa Creek
75	Banana Ranch	Cochetopa Creek
77	Lower Los Pinos	Los Pinos Creek
84	Lower Cochetopa	Cochetopa Creek
104	Flying M	Los Pinos Creek
123	Los Pinos #7	Los Pinos Creek
125	Pauline #1	Pauline Creek
126	Pauline #2	Pauline Creek
128	West Pass #1	Cochetopa Creek
East/Slate River		
34	Crested Butte (East	East River
35	Slate-East	East River
37	Cement	Cement Creek
46	Farris (Lower)	Farris Creek
52	East	East River
88	Brush	Brush Creek
89	Farris (Upper)	Farris Creek
90	North Village Reservoir	East River
91	Meridian Lake	Washington Gulch
92	Rozman	Washington Gulch
93	Grant Lake	Slate River Trib.
129	Oh-Be-Joyful	Of-Be-Joyful Creek
Ohio Creek Subbasin		
15	Castle	Ohio Creek
16	Upper Willow Park	Castle Creek
47	Hinkle	Ohio Creek
55	Lower Willow Park	Castle Creek
120	Castleton	Castle Creek
121	Castleton #2	Ohio Creek
122	Castleton #3	Ohio Creek
Tomichi Creek Subbasin		
13	Parlin	Tomichi Creek
18	Ohio City	Quartz Creek
32	Long Branch	Long Branch Creek
41	Tomichi	Tomichi Creek
44	Pitkin	Quartz Creek
72	Sargents #1	Tomichi Creek
73	Sargents (Sargents #3)	Tomichi Creek
76	Sargents #2	Tomichi Creek
78	Sargents #4	Tomichi Creek
79	Upper Razor	Razor Creek
80	Lower Razor	Razor Creek
81	Needle	Needle Creek
82	Sargents #3	Tomichi Creek
83	Crookton	Tomichi Creek
85	Elko	Tomichi Creek
100	Hartman Rock	Tomichi Creek
112	Ohio City #4	Quartz Creek
113	Ohio City #3	Quartz Creek
114	Ohio City #2	Quartz Creek
115	Ohio City #1	Quartz Creek
116	Monarch #5	Tomichi Creek
117	Monarch #4	Tomichi Creek
118	Monarch #3	Tomichi Creek
119	Monarch #2	Tomichi Creek
Cow Creek Subbasin		
67	Ramshorn	Cow Creek
69	Sneva	Dry Creek
109	Combs	Cow Creek



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

STORAGE SITES RETAINED FOR FURTHER STUDY

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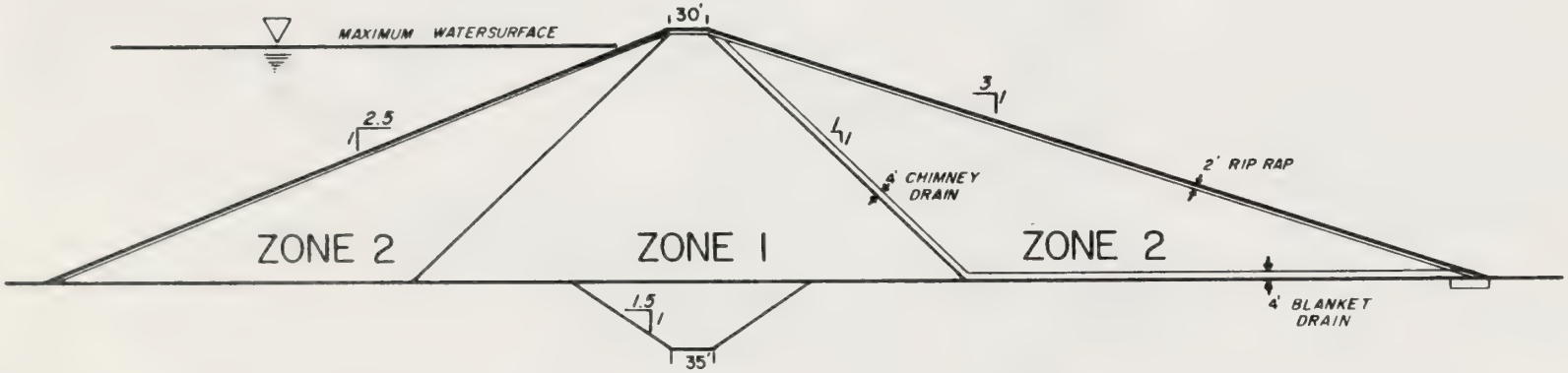
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE April 1989 FIGURE 12.3



0 100 200 300

SCALE IN FEET

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

TYPICAL ZONED EARTHFILL DAM SECTION

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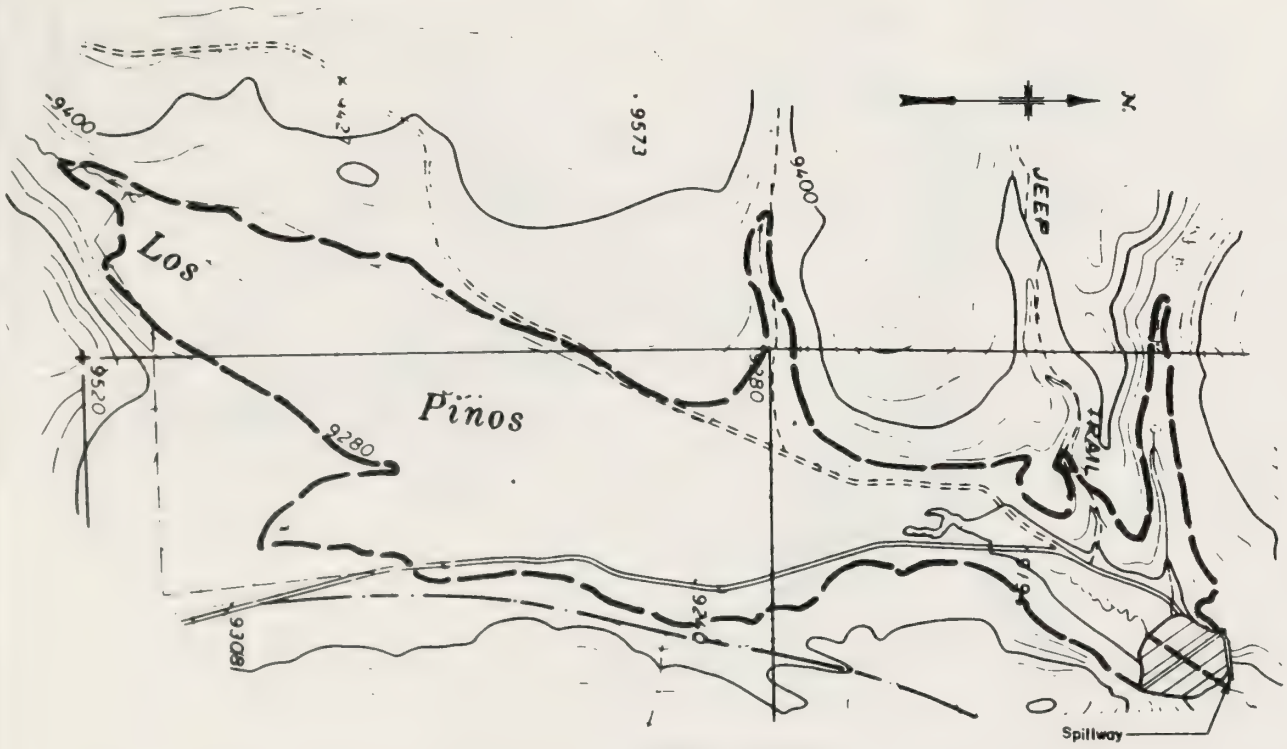
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE April 1989 FIGURE 12.4



SITE PLAN

DAM CREST LENGTH	800
DAM CREST ELEVATION	9, 299
SPILLWAY ELEVATION	9, 289
NORMAL WATER SURFACE ELEVATION	9, 289

LEGEND

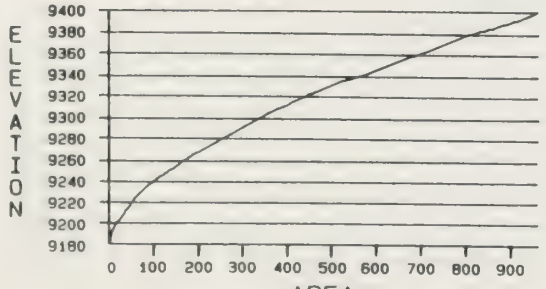
NORMAL WATER SURFACE ELEVATION

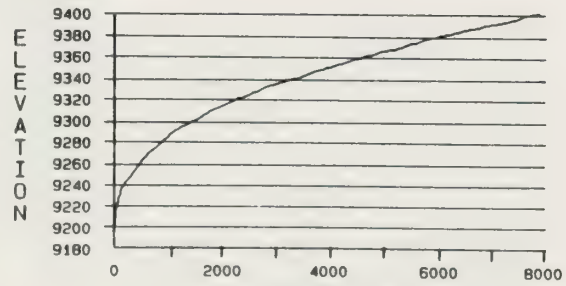
RESERVOIR OUTLET

ROAD RELOCATION

0 1000 2000 3000

SCALE IN FEET





COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

LOS PINOS PROJECT LAYOUT

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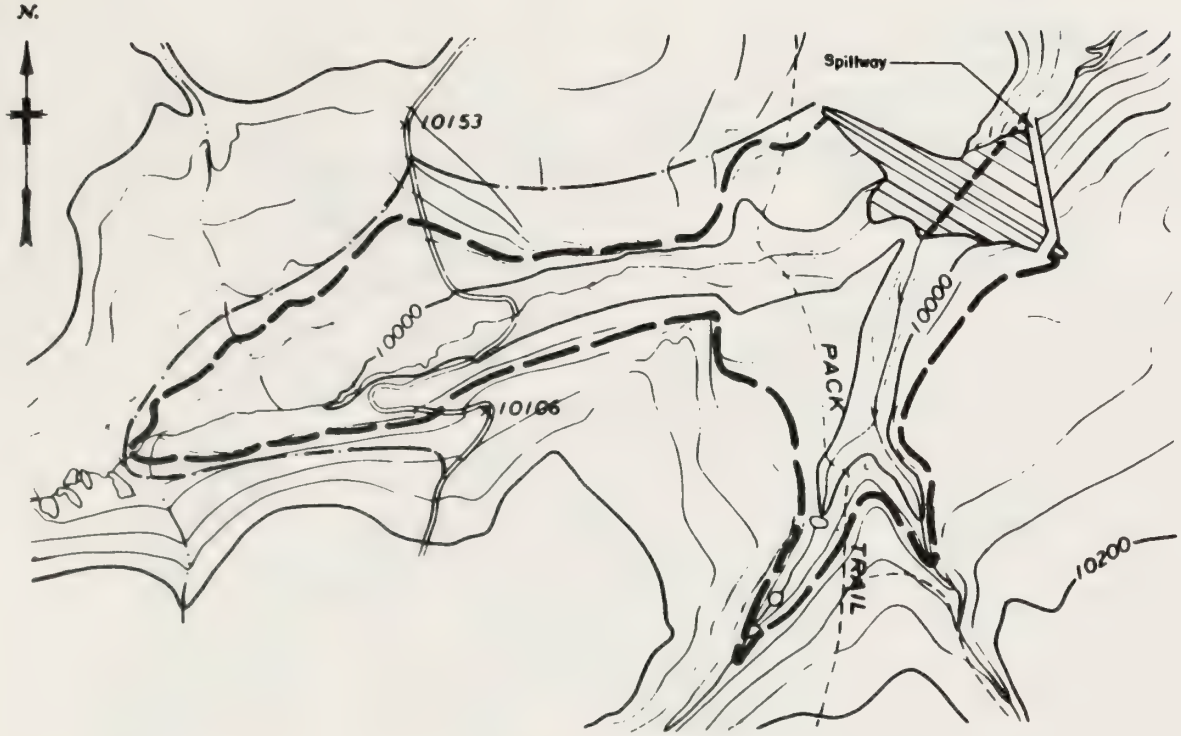
DATE April 1989 FIGURE 12.5



SITE PLAN

DAM CREST LENGTH	2, 100
DAM CREST ELEVATION	10; 069
SPILLWAY ELEVATION	10, 059
NORMAL WATER SURFACE ELEVATION	10, 059

LEGEND

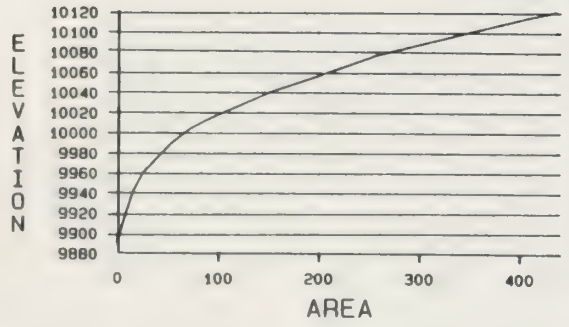
NORMAL WATER SURFACE ELEVATION

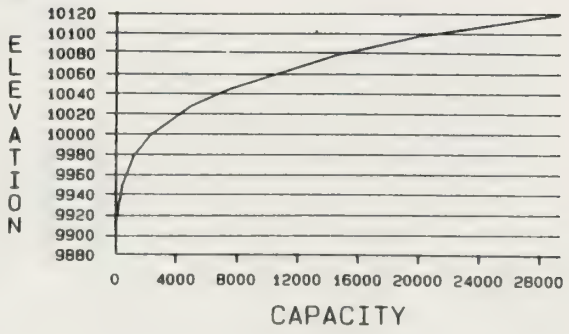
RESERVOIR OUTLET

ROAD RELOCATION

0 1000 2000 3000

SCALE IN FEET





COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

PAULINE PROJECT LAYOUT

HDR ENGINEERING, INC.
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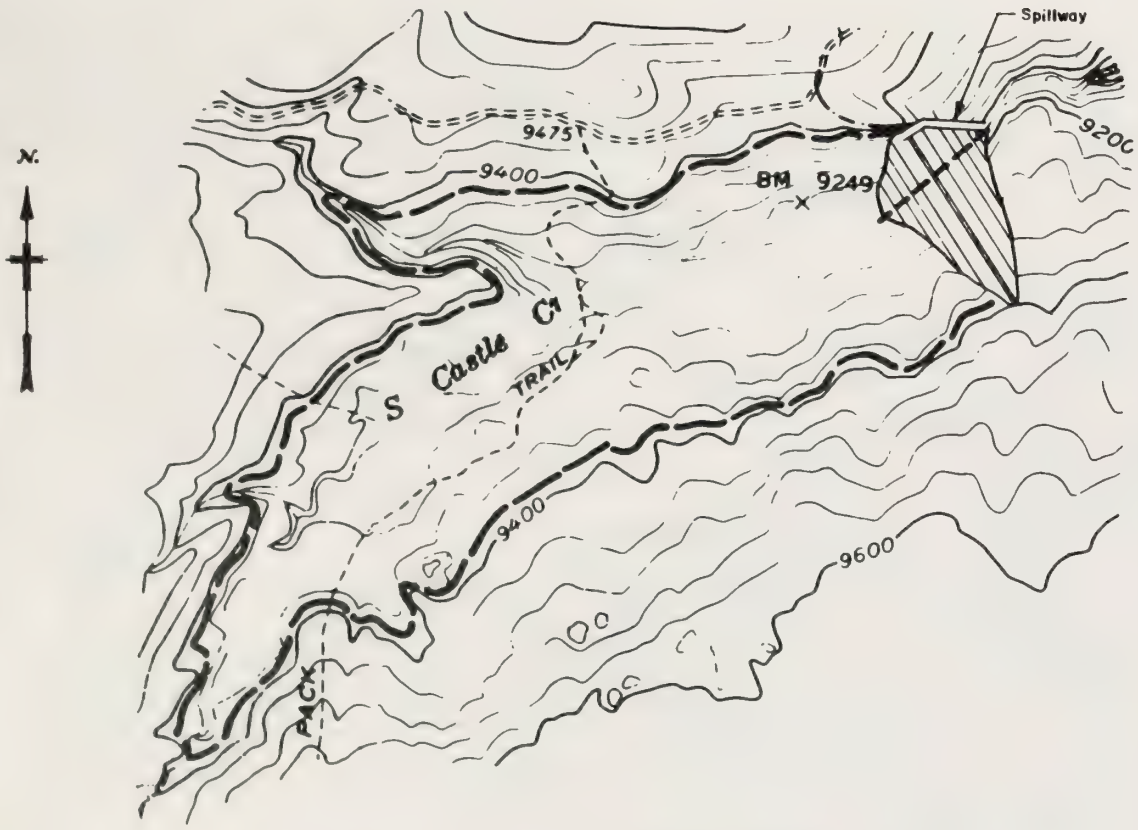
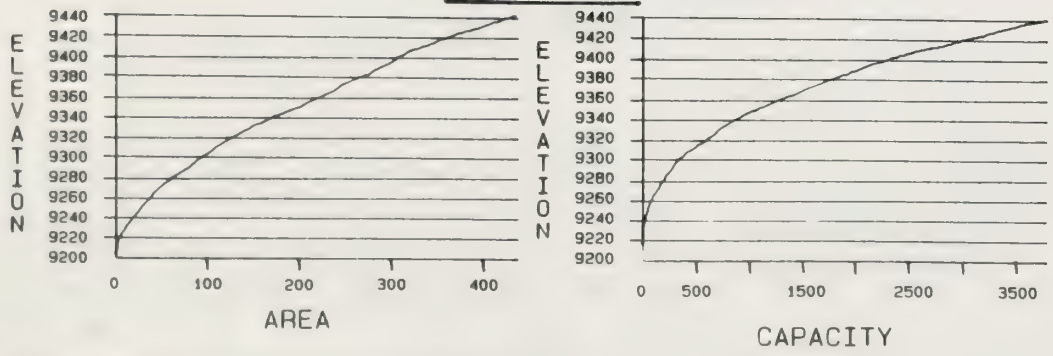
DATE April 1989 FIGURE 12.6



SITE PLAN



DAM CREST LENGTH	1, 550
DAM CREST ELEVATION	8, 399
SPILLWAY ELEVATION	8, 389
NORMAL WATER SURFACE ELEVATION	8, 389

LEGEND

NORMAL WATER SURFACE ELEVATION

RESERVOIR OUTLET

ROAD RELOCATION

0 1000 2000 3000

SCALE IN FEET

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

CASTLETON PROJECT LAYOUT

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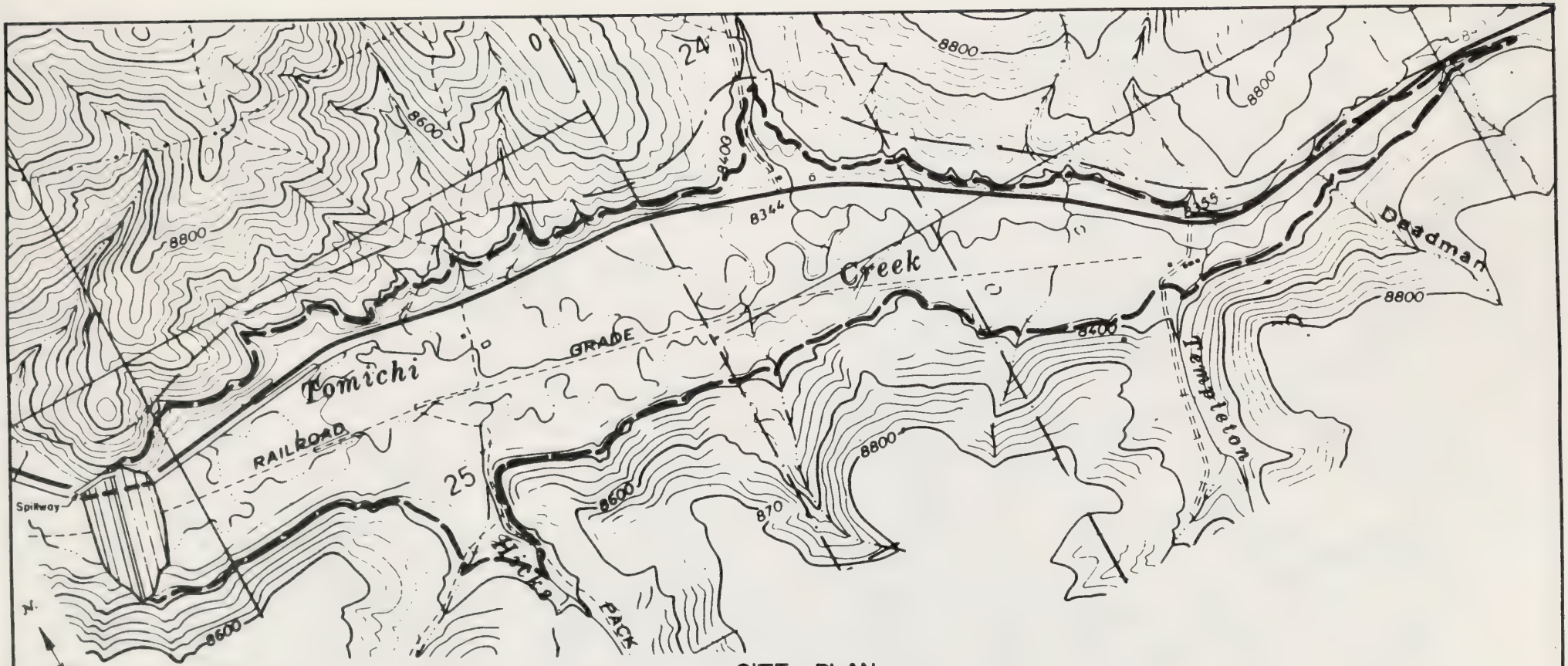
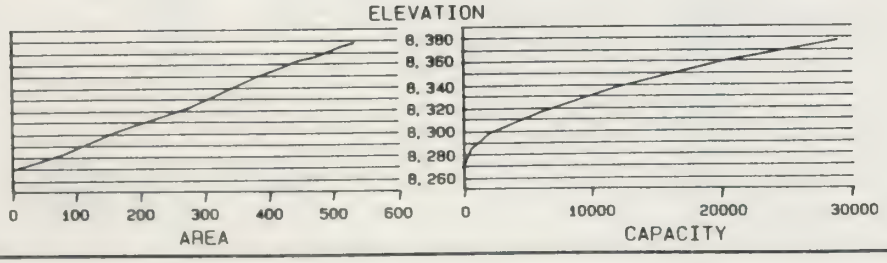
DATE **April 1989** FIGURE **12.7**



SITE PLAN

DAM CREST LENGTH	1, 350
DAM CREST ELEVATION	8, 391
SPILLWAY ELEVATION	8, 381
NORMAL WATER SURFACE ELEVATION	8, 381

0 1000 2000 3000
SCALE IN FEET



LEGEND

NORMAL WATER SURFACE ELEVATION
RESERVOIR OUTLET
ROAD RELOCATION

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

ELKO PROJECT LAYOUT

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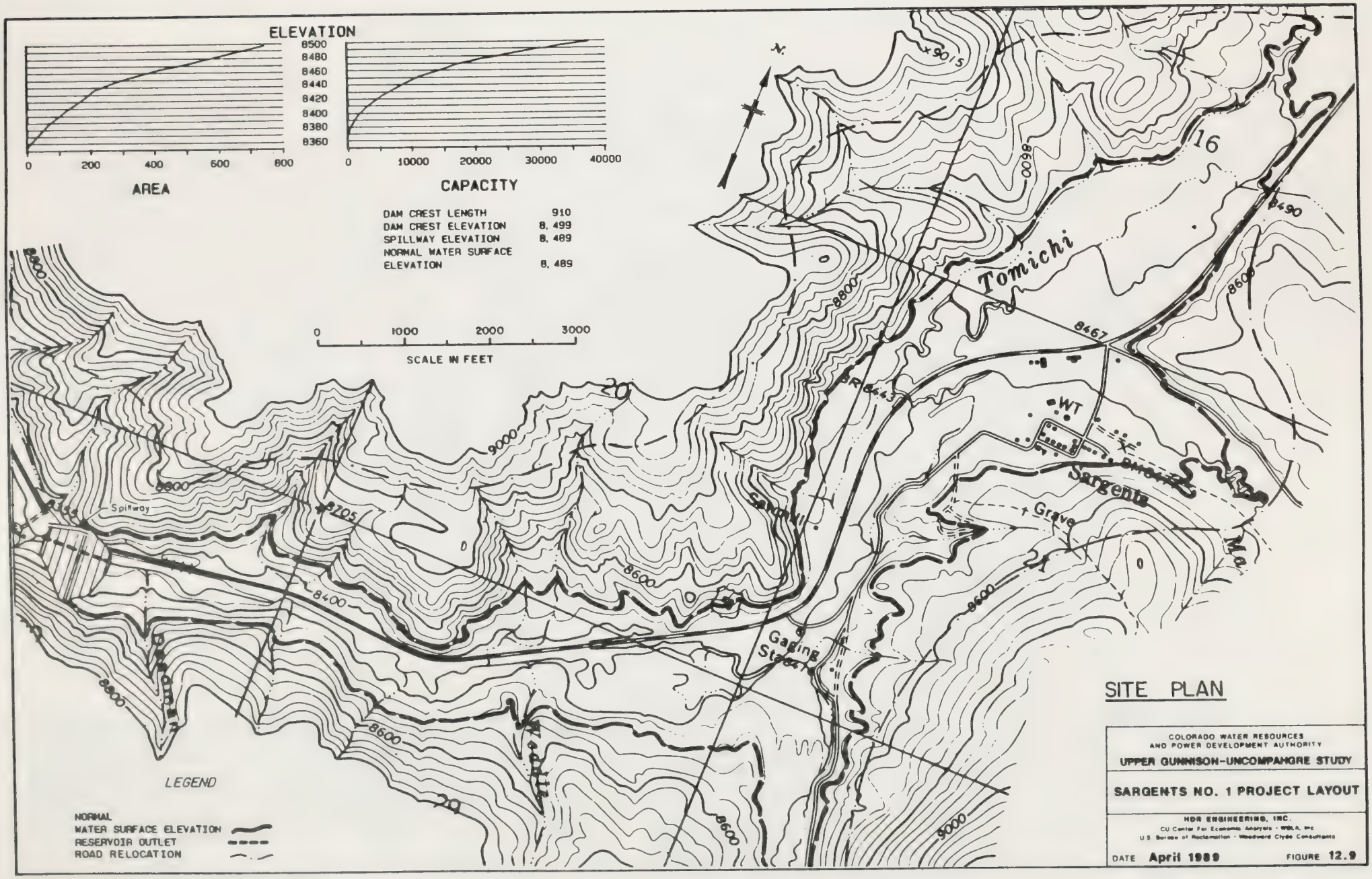
DATE **April 1989** FIGURE **12.8**


ELEVATION
8500
8480
8460
8440
8420
8400
8380
8360
0
200
400
600
800
AREA
0
10000
20000
30000
40000
CAPACITY
DAM CREST LENGTH 910
DAM CREST ELEVATION 8,499
SPILLWAY ELEVATION 8,489
NORMAL WATER SURFACE ELEVATION 8,489
0
1000
2000
3000
SCALE IN FEET
Tomichi
Sargents
Creek
Gaging Station
Spillway
WT
8467
8490
8600
8800
9000
8400
8705
16
20
LEGEND
NORMAL WATER SURFACE ELEVATION
RESERVOIR OUTLET
ROAD RELOCATION
SITE PLAN
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
SARGENTS NO. 1 PROJECT LAYOUT
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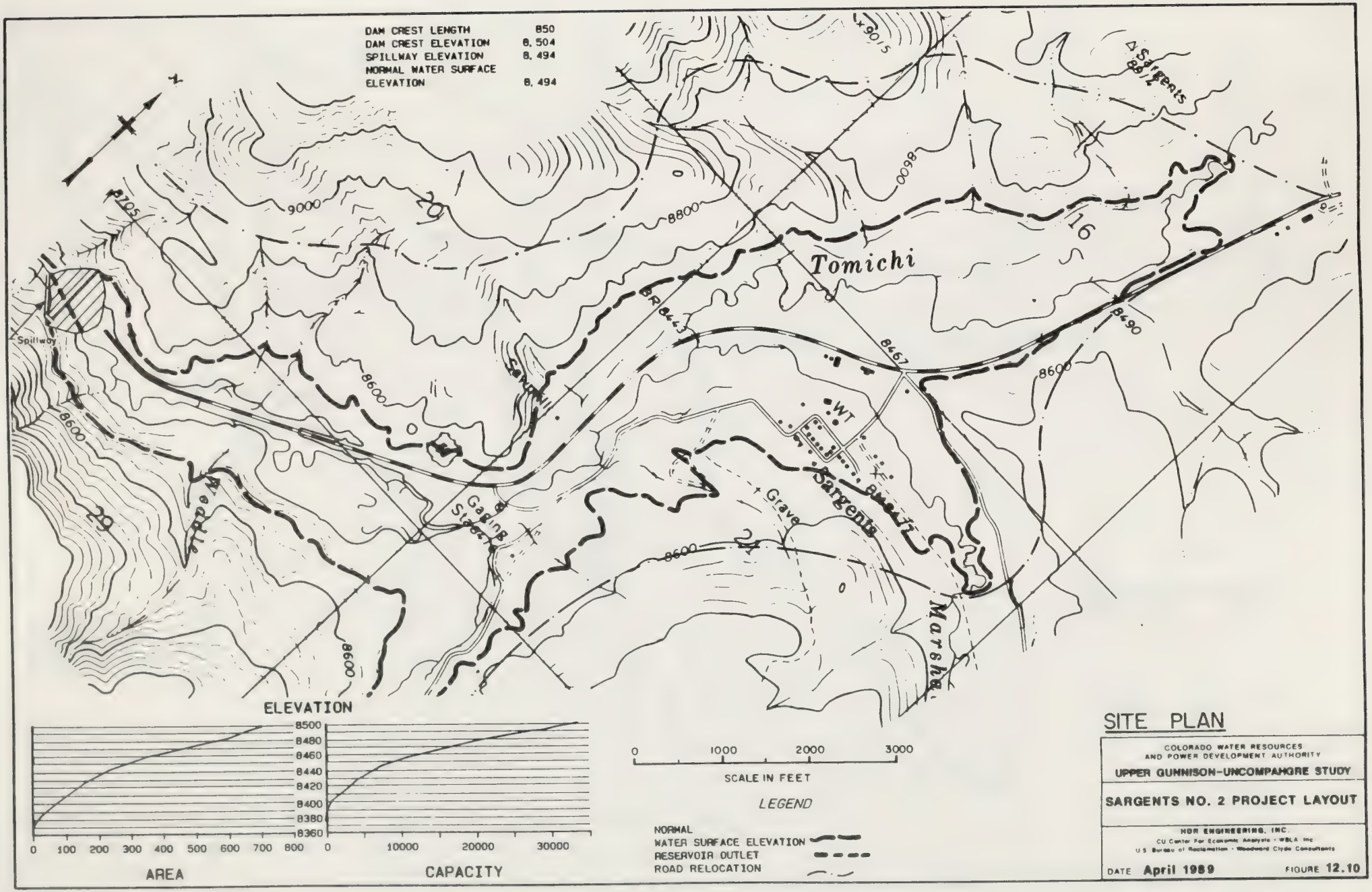
DATE April 1989
FIGURE 12.9



SITE PLAN

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

SARGENTS NO. 2 PROJECT LAYOUT

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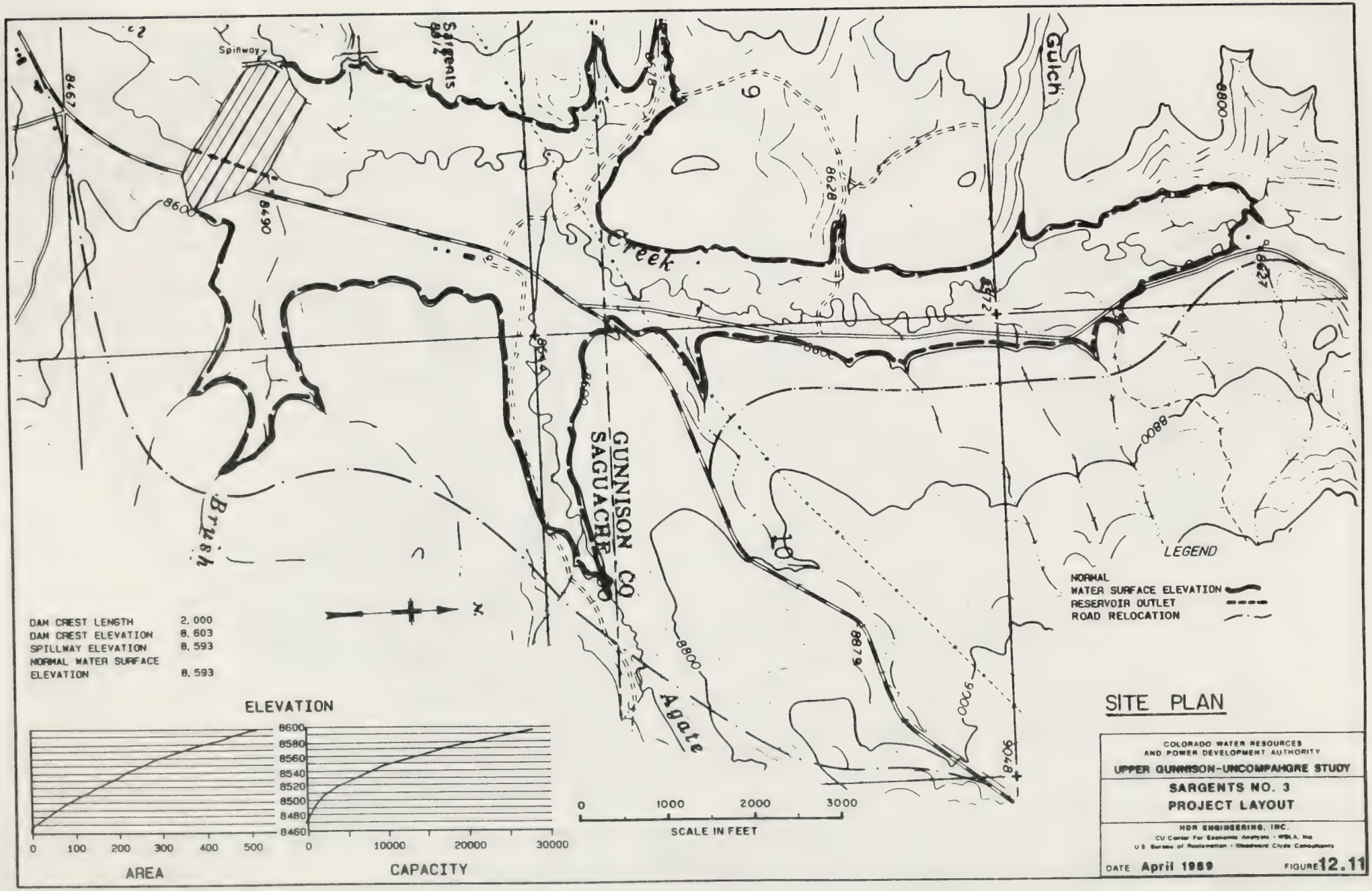
DATE April 1989 FIGURE 12.10


Spillway
Spargents
Gulch
Creek
Agate
GUNNISON CO
SAGUACHE CO
Brush
8662
8690
8628
8672
8927
8879
9048
8800
8600
9000
N
LEGEND
NORMAL
WATER SURFACE ELEVATION
RESERVOIR OUTLET
ROAD RELOCATION
DAM CREST LENGTH 2,000
DAM CREST ELEVATION 8,603
SPILLWAY ELEVATION 8,593
NORMAL WATER SURFACE ELEVATION 8,593
ELEVATION
8600
8580
8560
8540
8520
8500
8480
8460
0 100 200 300 400 500
AREA
0 10000 20000 30000
CAPACITY
0 1000 2000 3000
SCALE IN FEET
SITE PLAN
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
SARGENTS NO. 3
PROJECT LAYOUT
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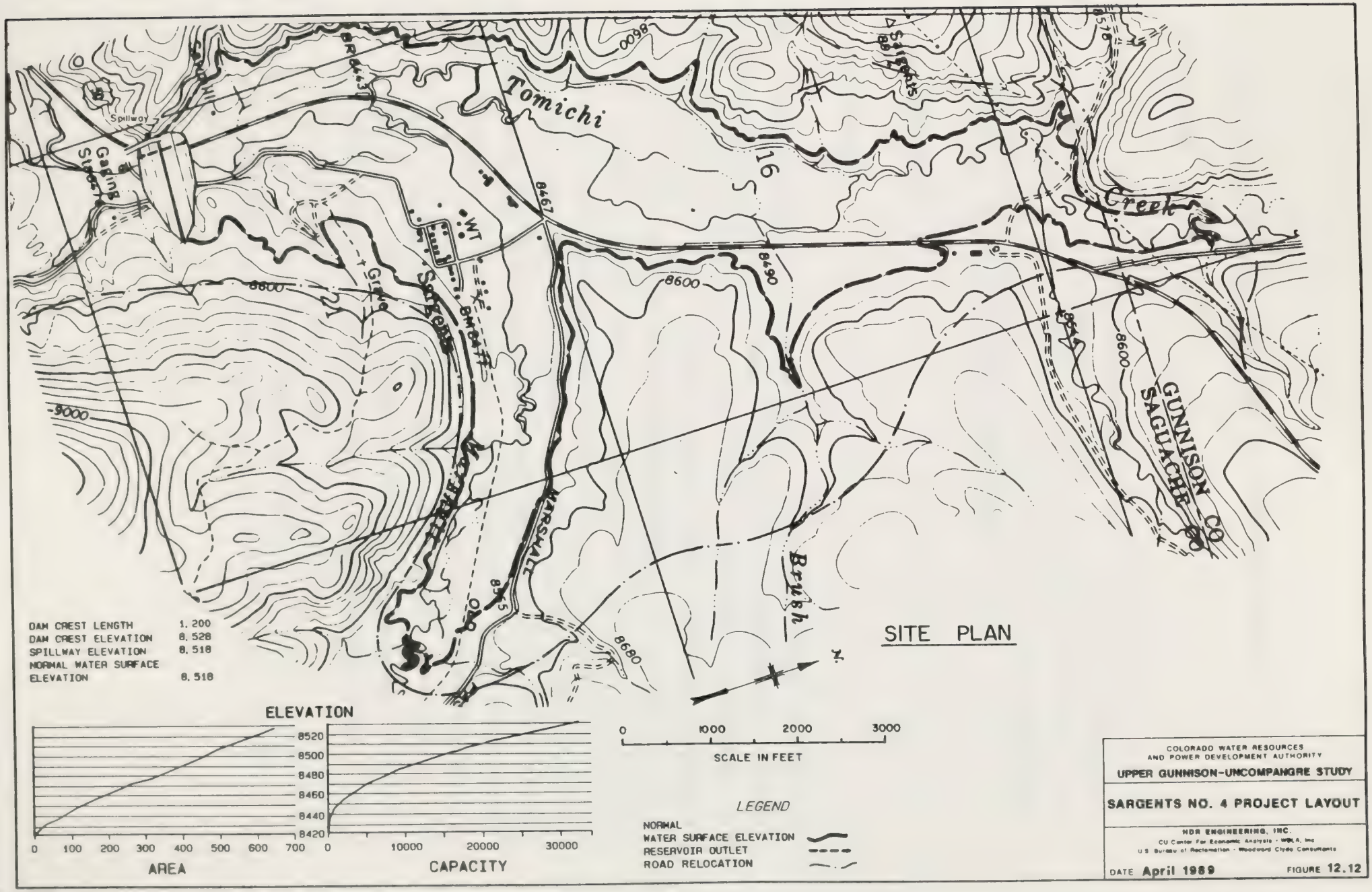
DATE April 1989
FIGURE 12.11



SITE PLAN

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

SARGENTS NO. 4 PROJECT LAYOUT

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DATE April 1989 FIGURE 12.12

13.0 FORMULATION AND EVALUATION OF ALTERNATIVE PLANS

13.1 INTRODUCTION

The previous three chapters discussed the identification, evaluation and screening of potential plan components. Table 13.1 presents a summary of components recommended for consideration in the plan formulation process. The components are grouped by category. The remainder of this chapter discusses how alternative plans were formulated and evaluated.

13.2 PLAN FORMULATION

13.2.1 Methodology

The primary purpose of this study is to define and recommend a plan for the integrated development of the water resources in the study area to serve the projected future needs of the study area. Therefore, combinations of recreational components, non-structural components, and structural components were identified considering the location and extent of forecasted in-basin future water demands. A plan formulation meeting was held on July 11, 1988 with the Authority, the Technical Steering Committee, and representatives of the Advisory Committee. The study team presented an overview of the screening process results and identified the recreational, non-structural and structural components recommended for consideration as components of alternative plans. The general make-up of alternative plans was discussed and input was obtained from the group. The study team then evaluated the input received at the meeting to identify six alternative plans which would be evaluated in detail. The six plans were identified with the intent of covering a broad spectrum of development possibilities. Plans consisting entirely of non-structural components, entirely of structural components, and combinations of structural and non-structural components were formulated to provide a range of potential development options.

TABLE 13.1

Components Recommended for Consideration in Plan Formulation

In-Basin Reservoirs

Storage Reservoir in the Ohio Creek Basin

Storage Reservoir in the Upper Cochetopa Basin

Storage Reservoir in the Upper Tomichi Basin

Recreation Components

Campsites along Gunnison
Trail and campsites along East River
Campsites along Taylor River
Campsites at Taylor Park Reservoir
Streamside trail and park along Tomichi Creek
Campsites in Cochetopa Canyon
Trail from Montrose to Ridgway Reservoir
Boat Access points on Taylor River
Improve Taylor River low flow boating
Boat access points on Gunnison River
Improve access to East River, Tomichi, and Quartz Creeks
Trophy fishery on Gunnison River
Study of trophy fishery in Blue Mesa
Trophy fishery on Taylor River
Monitor fishery on Uncompahgre River

Water Management and Conservation Measures

Water Rights Purchases, Exchanges and Transfers
Drought Insurance

13.2.2 Description of Alternative Plans

The six alternative plans are described in the following sections.

13.2.3 Alternative Plan No. 1

Alternative No. 1 consists of non-structural, recreation components. This plan includes all the recreation components that survived the screening and were identified in Chapter 11. Table 13.2 presents the elements which comprise this plan.

13.2.4 Alternative Plan No. 2

Alternative No. 2 consists of structural components; namely, three reservoirs of moderate size. The primary purpose of this alternative is to satisfy irrigation water shortages identified under the No-Action Alternative. These proposed reservoirs were sized to provide secondary benefits of in-stream flow enhancement, flatwater recreation, and flood control. Table 13.3 defines the components which comprise this alternative.

13.2.5 Alternative Plan No. 3

This alternative is the combination of Alternatives No. 1 and No. 2.

13.2.6 Alternative Plan No. 4

This alternative is a combination of Alternative No. 2 with selected elements of Alternative No. 1. The rationale behind including a limited number of selected recreation components is to limit capital costs while providing a reasonable level of recreation enhancement. Acceptance of this alternative implies that the remaining recreation components identified in Alternative No. 1 will be implemented at some future date as funds become available. Table 13.4 defines this alternative.

13.2.7 Alternative Plan Nos. 5 and 6

Alternative Nos. 5 and 6 are similar to Alternative No. 4 except that Alternative No. 5 includes two in-basin reservoirs and Alternative No. 6 includes one in-basin reservoir.

Alternative No. 5 includes the Upper Ohio Creek and Upper Tomichi Creek Reservoirs. These were selected because they serve areas with larger predicted irrigation shortages than the Upper Cochetopa Reservoir would serve

Alternative No. 6 includes the Upper Tomichi Reservoir which serves the sub-basin with the largest forecasted irrigation shortage.

TABLE 13.2

Definition of Alternative No. 1.

Component

- Manage instream flows, improve access on public sections and improve irrigation diversions on Gunnison River to develop a trophy-size, wild trout fishery.

- Manage instream flows, institute special regulations and provide public access on 1/4 mile of stream below Taylor Park Dam to develop a trophy-size, wild trout fishery in the Upper Taylor River.

- Study the potential for introducing large size trout in Blue Mesa Reservoir.

- Monitor conditions in the Uncompahgre River below Ridgway Dam to assess potential of developing a trout fishery.

- Provide public access to three miles of private property on the East River (short-term leases).

- Provide public access to eight miles of private property on Tomichi Creek between Marshall Creek and the Gunnison River (short term leases).

- Provide public access to three miles of private property on Quartz Creek. (short term leases).

- Provide two raft and boat access points on the Taylor River.

- Modify selected stream reaches and manage Taylor Reservoir releases to improve Taylor River rafting during low flow periods.

TABLE 13.2 (Continued)

Definition of Alternative No. 1.

Component

- Provide three raft and boat access points on the Gunnison River.
- Develop 25 campsites on the Gunnison River below Almont.
- Develop 10 campsites and 18 miles of streamside trail on the East River between Almont and Crested Butte.
- Develop 25 campsites on the Taylor River.
- Develop 30 RV campsites at Taylor Park.
- Develop four miles of streamside trail along Tomichi Creek through the City of Gunnison including a 3-acre park and 20 picnic sites.
- Improve 32 existing primitive campsites along Cochetopa Creek within Cochetopa Canyon.
- Develop 17 miles of Uncompahgre River trail from Montrose to Ridgway Reservoir.

TABLE 13.3

Definition of Alternative No. 2

This alternative consists of three multi-purpose water storage reservoirs to serve irrigation demands, provide instream flow enhancement, provide flatwater recreation, and to provide some measure of flood control. These reservoirs are as follows:

Ohio Creek Basin Reservoir.	A 20,000 af capacity facility in the Ohio Creek Basin. The Castleton project is used as being a representative site.
Cochetopa Basin Reservoir	A 10,000 af capacity reservoir located in the Upper Cochetopa Basin. The Pauline project is used as being a representative site.
Tomichi Basin Reservoir	A 25,000 af capacity reservoir located in the Upper Tomichi Basin. The Sargents No. 3 project is used as being a representative site.

TABLE 13.4

Definition of Alternative No. 4

This alternative consists of the Ohio Creek Basin Storage Reservoir, the Cochetopa Basin Reservoir, and the Tomichi Basin Reservoir and the following recreation components:

- Manage instream flows, improve access on public sections and improve irrigation diversions on Gunnison River to develop a trophy-size, wild rainbow trout fishery.
- Manage instream flows, institute special regulations and provide public access on 1/4 mile of stream below Taylor Park Dam to develop a trophy-size, wild rainbow trout fishery in the Upper Taylor River.
- Study the potential for introducing large size trout in Blue Mesa Reservoir.
- Provide public access to three miles of private property on the East River (short-term leases).
- Provide public access to eight miles of private property on Tomichi Creek between Marshall Creek and the Gunnison River (short-term leases).
- Modify selected stream reaches and manage Taylor Reservoir releases to improve Taylor River rafting during low flow periods.
- Provide three raft and boat access points on the Gunnison River.
- Develop 25 campsites on the Taylor River.
- Improve 32 existing primitive campsites along Cochetopa Creek within Cochetopa Canyon.
- Develop 17 miles of Uncompahgre River trail from Montrose to Ridgway Reservoir.

13.3 HYDROLOGIC/WATER RIGHTS EVALUATION OF ALTERNATIVE PLANS

The hydrologic/water rights computer model developed for this study and discussed in Chapter 7.0 was used to evaluate the alternative plans. The discussion of scenarios which follows focuses on the essential indicators of water supply system performance. Conditions in specific areas of shortage or instream flow deficiency identified in Scenario 1 were monitored in detail and overall system performance was monitored by observing modeled conditions at key river reaches, storage reservoirs, and diversion points.

The recreation components included in alternative plans do not consume water although several of them may require management of streamflow through changes in reservoir release patterns. When modeling alternative plans, it was not necessary to include these components since they do not consume water and because modifications to reservoir release patterns will ultimately be established such that downstream water users will not be adversely impacted. Therefore, model runs of alternative plans did not specifically include any water rights for proposed recreation components. However, the modeled flows in key recreational use areas provide an indication of the effect of the plans on existing or potential recreational uses.

Based on the discussion above, only Alternative No. 2 was modeled. If Alternative No. 1 (all recreation components) were modeled, the results would be the same as for Scenario 1. The results of modeling Alternative No. 4 (combination of Alternatives 1 and 2) would be the same as the results obtained from Alternative No. 2. Modeling of Alternatives 5 and 6 would be different than the results obtained from Alternative No. 2 because fewer storage reservoirs are included in these alternatives. However, mainly because of the Curecanti subordination, the hydrologic effects of development of any combination of the three in-basin reservoirs are practically independent. The principal basin-wide effect of developing more than one in-basin reservoir is to increase late season inflow to Blue Mesa Reservoir. Because of this independence between basins, only the combination of three reservoirs, Alternative No. 2, was evaluated and is discussed in this chapter.

The term "Scenario" as used herein refers to hydrologic/water rights computer model runs. A number of computer model runs will be required to evaluate the water yields and effects of alternative plans. For example, if a plan includes a proposed reservoir, several computer runs may be made in order to evaluate the effect of different in-stream flow regimes (CWCB decrees versus higher values to achieve enhanced recreation) below the reservoir prior to estimating the recommended reservoir size. Thus, Alternative Plan No. 2 may have scenarios (model runs) 4, 5, and 6 associated with it.

13.3.1 Description of Scenarios for Alternative No. 2

Five alternative in-basin reservoirs in three sub-basins survived the screening process. However, a maximum of three reservoirs, one in each of the sub-basins are being considered. Five of the eight reservoirs were evaluated using the basin model. These reservoirs include Castleton on Ohio Creek, Elko and Sargents No. 3 on Tomichi Creek, and Los Pinos and Pauline in the upper Cochetopa drainage.

Scenario 2A evaluated a combination of Castleton, Elko, and Los Pinos reservoirs. Results of this scenario showed that certain agricultural shortages and instream flow deficiencies remained with the reservoirs in place. The results also showed that the shortages could be eliminated or reduced by moving to storage sites farther upstream on Tomichi and Cochetopa Creeks. Therefore, Scenario 2B evaluated a combination of Castleton, Sargents No. 3, and Pauline reservoirs. Both scenarios assumed that no transbasin export occurred.

13.3.2 Water Rights and Operating Rules

The storage of water in the in-basin reservoirs was assumed to occur under conditional decrees presently held by the Upper Gunnison River Water Conservancy District. The decrees which could most readily be transferred to support the new reservoirs are listed in Table 13.5. Transfer of these decrees would require Water Court proceedings but that does not appear to be a

serious problem since such transfers do not cause injury to any other modeled in-basin rights. In addition, the Curecanti subordination protects these other future junior depletions from the effects of such transfers.

TABLE 13.5

Upper Gunnison Project Water Rights
Used for In-basin Reservoirs

Reservoir	Assumed Size	Decree Transferred	Decree Size
Castleton	20,000 af	Castleton	9,000 af
		Soap Park	87,000 af
Sargents No. 3	25,000 af	Monarch	29,201 af
Pauline	10,000 af	Banana Ranch	21,733 af

The reservoirs were allowed to store water in priority and to spill when full. They were operated to satisfy agricultural supply shortages and to meet enhanced instream flow targets when possible. Releases were made on demand to satisfy both of these water needs.

Instream flow targets for enhanced fishery habitat were discussed previously in Chapter 11.0 and the methodology for computing the values was presented in that discussion. The enhanced instream flow targets were developed from statistics of virgin flow on Ohio, Tomichi, and Cochetopa Creeks and are based on fishery and recreational considerations. On all streams the enhanced instream flow targets are equal to or higher than the CWCB decreed values. Enhanced instream flow targets were developed for each modeled reach on each of the three tributaries. However, usually only one

reach on each tributary acted on the controlling reach, calling instream flow water through the other reaches and satisfying them in the process. The controlling reaches and their associated flow targets are:

Ohio Creek at Mouth	29 cfs year-round
Tomichi Creek Above Razor Creek	18 cfs winter, 31 cfs summer
Cochetopa Creek above Los Pinos Creek	9 cfs winter, 15 cfs summer

13.3.3 Performance of In-basin Reservoirs, Scenario 2B

The performance of the in-basin reservoirs was estimated mainly by assessing agricultural demands and instream flow conditions on the respective streams. Recreation potential of the reservoirs was evaluated by examining reservoir level fluctuations. System effects were monitored by conditions at several other key stream reaches, storage reservoirs, and points of diversion elsewhere in the basin.

The three reservoirs were able to eliminate shortages to agricultural depletion demands, as identified in Scenario 1, on all three streams. Instream flow targets were met or exceeded throughout the 32-year study period (1952-1983) on Ohio and Tomichi Creeks, but not on upper Cochetopa and Pauline Creeks, where insufficient physical supply caused infrequent deficiencies. Tables 13.6 through 13.8 list monthly instream flows occurring in critical sections of Ohio, Tomichi, and Cochetopa Creeks with the three reservoirs in place.

Recreation potential on Castleton and Sargents No. 3 reservoirs appears good. As shown on Figures 13.1 and 13.2, these reservoirs fill regularly and are substantially full most of the time. Pauline reservoir, shown on Figure 13.3, is often very low or near empty because of the lack of physical supply. Blue Mesa storage levels under this scenario are slightly lower than under Scenario 1. Blue Mesa Reservoir water levels are depicted in Figure 13.4 and the comparison of water levels between Scenarios 2B and 1 is shown in Figure 13.5.

The Taylor Park Exchange Agreement stipulates that the UVWUA be given a credit to draw on Blue Mesa storage in direct proportion to Taylor Park Reservoir releases made in excess of tunnel diversions up to an amount equal to their Taylor Park storage decree. Flows downstream of Taylor Park Dam tunnel diversions and Blue Mesa inflows are monitored to keep track of credits and debits to the "exchange account." Late season releases from the three reservoirs increase inflows to Blue Mesa and reduce the need for the senior Gunnison Tunnel diversion decree to draw water from Taylor Park Reservoir storage. This reduces the draw on UVWUA's storage credit in Blue Mesa and results in the Taylor Park Exchange account showing a higher storage credit than in Scenario 1. Figure 13.6 depicts the status of total storage held by the UVWUA in the exchange account over the 32-year period of record modeled. The average monthly exchange credit under Scenario 2B is 5228 af/mo, compared to 4857 af/mo in Scenario 1.

Gunnison Tunnel diversions are negligibly different from Scenario 1, and Blue Mesa releases are able to maintain the target 300 cfs minimum instream flow in the Black Canyon without any appreciable difference in Blue Mesa Reservoir levels compared to Scenario 1.

TABLE 13.6

Ohio Creek at Mouth

Average Monthly Flow (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	29	35	29	29	29	29	85	380	589	125	52	38	117
1953	32	31	29	29	29	29	45	160	326	57	30	29	69
1954	29	31	29	29	29	29	72	126	29	29	29	29	41
1955	38	31	29	29	29	29	65	151	300	33	30	29	48
1956	29	30	29	29	29	29	79	294	220	29	29	29	71
1957	29	31	29	29	29	29	45	199	652	445	109	46	140
1958	37	35	29	29	29	29	53	446	283	29	29	29	88
1959	29	29	29	29	29	29	45	125	191	29	29	29	52
1960	30	36	29	29	29	29	95	137	202	29	29	29	59
1961	30	31	29	29	29	29	45	172	300	29	29	29	46
1962	50	43	36	29	33	31	114	344	398	128	31	29	106
1963	29	29	29	29	29	29	60	194	31	29	29	29	46
1964	29	29	29	29	29	29	33	189	125	53	30	29	53
1965	29	30	29	29	29	29	53	313	520	303	70	60	125
1966	53	37	32	29	29	29	85	234	104	29	29	29	60
1967	29	29	29	29	29	29	73	205	261	84	32	34	72
1968	34	30	31	29	29	29	41	217	405	77	62	29	84
1969	34	31	29	29	29	29	95	382	217	98	33	33	87
1970	44	36	31	29	29	29	41	428	384	97	34	58	102
1971	44	37	32	31	29	29	97	201	353	119	38	33	87
1972	34	35	29	29	29	32	72	190	224	29	29	29	63
1973	37	36	29	29	29	29	36	222	326	148	45	29	83
1974	31	29	29	29	29	31	58	327	216	38	29	29	73
1975	29	31	29	29	29	29	40	170	361	232	49	29	88
1976	29	29	29	29	29	29	62	174	196	49	29	29	59
1977	31	29	29	29	29	29	53	38	29	29	29	29	32
1978	29	29	29	29	29	29	67	207	303	145	36	29	80
1979	29	31	31	29	29	29	60	348	437	178	47	29	107
1980	31	31	29	29	29	29	57	306	510	135	29	29	104
1981	31	31	29	29	29	29	48	75	87	29	29	29	40
1982	29	31	29	29	29	29	48	200	335	145	47	45	83
1983	45	35	31	29	29	29	38	136	434	191	60	33	91
Average	34	32	30	29	29	29	61	227	291	100	39	33	77
Std.Dev	7	3	1	0	1	1	20	98	153	92	17	8	26
Maximum	53	43	36	31	33	32	114	446	652	445	109	60	140
Minimum	29	29	29	29	29	29	33	38	29	29	29	29	32
CWCB DECREE	12	12	12	12	12	12	12	12	12	12	12	12	
ENHANCED ISF TARGET	29	29	29	29	29	29	29	29	29	29	29	29	

TABLE 13.7

Tomichi Creek Above Razor Creek

Average Monthly Flow (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	20	20	20	20	20	20	93	332	266	56	32	38	78
1953	30	24	26	31	29	42	53	115	175	43	31	33	53
1954	20	20	23	23	29	28	31	33	33	33	33	33	28
1955	20	20	20	20	20	20	31	31	33	33	33	33	26
1956	20	20	20	20	20	19	31	31	33	33	33	33	26
1957	20	20	20	20	20	19	31	54	457	232	84	68	87
1958	58	42	31	29	32	34	102	366	166	33	33	33	80
1959	20	20	20	20	20	18	33	48	41	33	32	33	28
1960	20	20	20	20	20	18	81	104	98	33	33	33	42
1961	20	20	20	20	20	18	31	31	33	33	33	33	26
1962	20	20	20	20	20	19	104	226	102	33	31	33	54
1963	20	20	20	20	20	44	41	38	33	33	33	33	30
1964	20	20	20	20	20	20	31	54	77	33	32	33	32
1965	20	20	20	20	20	24	95	183	228	129	66	65	74
1966	52	34	31	33	25	37	44	69	33	33	33	33	38
1967	20	20	20	20	20	18	31	31	33	33	33	33	26
1968	20	20	20	20	20	18	31	31	48	33	56	43	30
1969	30	25	23	26	27	41	63	87	87	62	31	33	45
1970	79	44	36	36	36	36	92	417	187	72	55	109	100
1971	74	44	37	46	36	44	55	106	118	56	34	46	56
1972	48	35	28	29	34	59	48	71	81	33	33	33	44
1973	20	20	20	20	20	18	39	198	222	80	31	33	60
1974	31	25	21	23	22	49	53	113	33	33	33	33	39
1975	20	20	20	20	20	18	31	137	194	95	34	33	54
1976	24	29	29	31	36	36	63	74	73	33	32	33	41
1977	20	24	21	20	20	19	31	33	33	33	33	33	27
1978	20	20	20	20	20	20	31	31	31	33	33	33	26
1979	20	20	20	20	20	18	31	130	177	46	31	33	47
1980	20	20	20	20	27	19	58	169	173	33	33	33	52
1981	20	20	20	20	20	19	31	32	33	33	33	33	26
1982	20	20	20	20	20	18	31	31	121	47	39	79	39
1983	73	37	33	21	25	36	43	130	357	120	55	45	81
Average	29	24	23	23	24	27	50	110	119	53	38	40	47
Std.Dev	18	8	5	6	6	11	24	100	103	41	12	17	21
Maximum	79	44	37	46	36	59	104	417	457	232	84	109	100
Minimum	20	20	20	20	20	18	31	31	31	33	31	33	26
CWCB DECREE	18	18	18	18	18	18	18	18	18	18	18	18	
ENHANCED ISF TARGET	18	18	18	18	18	18	31	31	31	31	31	31	

TABLE 13.8

Cochetopa Creek Above Los Pinos Creek

Average Monthly Flow (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	15	19	17	17	18	18	64	89	120	36	29	20	38
1953	17	19	18	19	18	23	38	38	71	28	27	18	27
1954	17	20	17	15	16	18	20	22	24	20	18	24	19
1955	15	15	14	10	9	11	28	12	3	0	17	8	12
1956	7	12	11	11	11	11	37	38	24	17	16	10	17
1957	8	15	10	10	11	15	39	87	163	85	53	30	41
1958	25	24	20	17	18	20	47	111	84	14	16	19	34
1959	17	20	16	17	16	20	27	19	19	19	20	22	19
1960	22	20	17	15	16	23	40	31	37	15	17	22	23
1961	17	19	17	15	16	20	25	15	11	17	15	18	17
1962	20	24	18	15	16	18	57	63	40	22	19	20	26
1963	18	17	15	15	18	28	25	15	11	19	16	13	18
1964	10	12	8	9	11	11	34	42	30	19	23	15	19
1965	13	20	19	17	12	15	46	54	91	56	44	29	34
1966	23	22	18	18	18	22	27	23	15	15	19	20	20
1967	13	10	17	15	16	20	10	15	20	14	17	18	17
1968	15	19	13	10	13	18	24	21	38	19	43	22	21
1969	18	19	17	17	14	21	34	28	35	32	25	19	23
1970	31	25	20	18	19	20	44	113	68	35	37	41	39
1971	30	25	22	22	19	23	30	35	45	29	27	24	28
1972	23	22	18	17	19	28	29	24	31	15	16	18	22
1973	20	20	17	17	18	18	27	57	76	38	26	20	29
1974	19	19	15	15	16	25	30	34	16	15	20	22	20
1975	19	19	17	15	14	17	34	45	68	44	28	17	28
1976	17	20	18	18	19	20	34	25	31	17	24	19	22
1977	20	19	17	13	16	15	19	24	24	22	13	5	17
1978	10	12	10	10	11	21	32	28	45	18	16	22	19
1979	15	19	12	7	7	16	37	49	62	26	22	18	24
1980	15	20	17	17	16	17	32	49	62	21	17	17	25
1981	16	19	15	15	16	15	17	17	20	14	11	9	15
1982	11	15	11	8	9	16	25	31	55	27	30	34	23
1983	28	24	20	15	15	20	27	39	110	44	30	24	34
Average	18	19	16	15	15	19	33	40	47	25	24	20	24
Std.Dev	5	3	3	3	3	4	10	25	34	15	10	7	7
Maximum	31	25	22	22	19	28	54	113	153	85	53	41	41
Minimum	7	12	8	7	7	11	17	12	3	0	11	5	12
CWCB DECREE	9	9	9	9	9	9	9	9	9	9	9	9	
ENHANCED 1ST TARGET	9	9	9	9	9	9	15	15	15	15	15	15	

13.4 EVALUATION AND RANKING OF ALTERNATIVE PLANS

13.4.1 Screening Criteria

In order to accomplish the broad range of project objectives, the recommended management plan should meet the following target objectives:

1. Satisfy projected future municipal and industrial water demands within the study area.
2. Provide high quality recreation opportunities that will result in increased tourism and related economic benefits to the study area and to the State of Colorado.
3. Assure that an adequate water supply will be available to support the recreational opportunities proposed as a result of meeting objective 2 above.
4. Satisfy projected future agricultural water demands in the study area.
5. Preserve the critical aspects of the environment, such as water quality, to the maximum practicable extent consistent with the other target objectives.

Alternative plans were formulated to meet all or a significant portion of the target objectives stated above. The alternative plans were evaluated and screened in order to rank them based on technical, environmental, institutional/social, and cost factors. An overall rank was assigned to each of these categories based on the ratings received on the subdivisions within each factor. The plans were then compared on the basis of the overall rank of each factor in order to arrive at a prioritized listing and identification of the preferred alternative. This process was reviewed with the Authority and the Study committee at the June 21, July 11 and November 15, 1988 meetings. The screening format for alternative plans is illustrated in Table 13.9 while an example of the Alternative Plan Comparison Table is depicted in Table 13.10. The actual screening tables for each alternative plan are included in Appendix G and the results are discussed in the following sections.

TABLE 13.9

Screening Criteria for Alternative Plans

Technical Evaluation:

Factor	Ranking		
	Low	Moderate	High
Meet Target Objective 1			
Meet Target Objective 2			
Meet Target Objective 3			
Meet Target Objective 4			
Meet Target Objective 5			
Relocations			
Reliability			
Overall Rank			

Environmental Evaluation:

Factor	Ranking		
	Potentially Detrimental to Present Condition	Neutral	Potentially Beneficial to Present Condition
Wildlife			
Fishery			
Botany			
Cultural Resources			
Recreation			
Water Quality			
Overall Rank			

Institutional/Social Evaluation:

Factor	Ranking		
	Severe Problems Expected	Some Difficulty Expected	No Significant Problems Expecte
Public Acceptance			
Land Use Conflicts			
Land Acquisition			
Water Rights			
Overall Rank			

Economic Evluation

Total Cost: _____

Annual Capital Cost of Storage:
In-Basin Storage: _____

Annual Capital Cost of Hydro:
Conventional: _____

TABLE 13.10

Alternative Plan Comparison Table

Alternative Plan	Overall Ranking			Cost	Other Factors, Explain and Assign Ranking
	Technical	Environmental	Institutional/Social		

13.4.2 Cost Estimates

Alternative Plan No. 1 consists entirely of recreation components. It is recognized that this alternative might not be financed entirely with the proceeds of a revenue bond offering, it was assumed that Alternative No. 1 would be financed in the same manner as other, more costly alternatives with the exception that the term of the debt was assumed to be 20 years instead of 30.

Other alternative plans which include recreation components were treated slightly different in that the cost of the recreation components was added to the cost of the other components (dams) and it was assumed that the plan would be financed as one, 30-year term package. The resulting estimates are presented in Tables 13.11 through 13.16.

13.4.3 Plan Evaluation and Ranking

Each plan was evaluated using the screening sheets (Table 13.9). If a "Low" ranking was assigned to any of the "Meet Target Objective" factors of the Technical Evaluation, then the overall rank for Technical Evaluation was assigned as Low regardless of the ranking obtained for the remaining factors in that category. The assignment of Overall Rank in the other evaluation categories was made subjectively based on data and information collected/developed during the study. The individual ranking sheets for each alternative plan are presented in Appendix G.

The overall rank and cost data for each individual plan was transferred from the individual plan evaluation sheet to the Alternative Plan Comparison Table for comparison and determination of the relative rank of each plan. The completed table is presented in Table 13.17. The relative ranking assigned to each alternative plan is presented below:

TABLE 13.11

Preliminary Cost Estimate - Alternative No. 1

INVESTMENT COST :	
1) Total Plan Construction Cost	$6,525,000
Interest During Construction (8% over six months)	$261,000
Total Plan Capital Cost	$6,786,000
Debt Service Reserve Fund (1 year debt service)	$795,000
Financing Expenses (3% of capital cost plus debt service reserve)	$227,000
Total Investment Cost	$7,809,000
ANNUAL COST :	
Annual Debt Service (8% over 20 years)	$795,000
Annual Lease and/or O&M Cost	$104,000
Total Annual Cost	$899,000

1) See Table 11.8 for breakdown.

TABLE 13.12

Preliminary Cost Estimate - Alternative No. 2

INVESTMENT COST :	
Total Capital Cost of Ohio Creek Reservoir	$23,504,000
Total Capital Cost of Tomichi Creek Reservoir	$29,167,000
Total Capital Cost of Cochetopa Creek Reservoir	$21,926,000
Total Plan Capital Cost	$74,597,000
Debt Service Reserve Fund (1 year debt service)	$7,392,000
Financing Expenses (1 1/2% of capital cost plus debt service reserve)	$1,230,000
Total Investment Cost	$83,219,000
ANNUAL COST :	
Annual Debt Service (8% over 30 years)	$7,392,000
Annual Lease and/or O&M Cost	$168,000
Total Annual Cost	$7,560,000

TABLE 13.13

Preliminary Cost Estimate - Alternative No. 3

INVESTMENT COST :	
Total Construction Cost of Recreation Components	$6,525,000
Total Construction Cost of Ohio Creek Reservoir	$20,900,000
Total Construction Cost of Tomichi Creek Reservoir	$25,936,000
Total Construction Cost of Cochetopa Creek Reservoir	$19,497,000
Total Plan Construction Cost	$72,858,000
Interest During Construction (8% over three years)	$9,077,000
Total Plan Capital Cost	$81,935,000
Debt Service Reserve Fund (1 year debt service)	$8,120,000
Financing Expenses (1 1/2% of capital cost plus debt service reserve)	$1,351,000
Total Investment Cost	$91,405,000
ANNUAL COST :	
Annual Debt Service (8% over 30 years)	$8,120,000
Annual Lease and/or O&M Cost	$271,500
Total Annual Cost	$8,391,500

TABLE 13.14

Preliminary Cost Estimate - Alternative No. 4

INVESTMENT COST :	
Total Construction Cost of Recreation Components	$2,580,000
Total Construction Cost of Ohio Creek Reservoir	$20,900,000
Total Construction Cost of Tomichi Creek Reservoir	$25,936,000
Total Construction Cost of Cochetopa Creek Reservoir	$19,497,000
Total Plan Construction Cost	$68,913,000
Interest During Construction (8% over three years)	$8,586,000
Total Plan Capital Cost	$77,499,000
Debt Service Reserve Fund (1 year debt service)	$7,680,000
Financing Expenses (1 1/2% of capital cost plus debt service reserve)	$1,278,000
Total Investment Cost	$86,456,000
ANNUAL COST :	
Annual Debt Service (8% over 30 years)	$7,680,000
Annual Lease and/or O&M Cost	$225,000
Total Annual Cost	$7,905,000

TABLE 13.15

Preliminary Cost Estimate - Alternative No. 5

INVESTMENT COST :	
Total Construction Cost of Recreation Components	$2,580,000
Total Construction Cost of Ohio Creek Reservoir	$20,900,000
Total Construction Cost of Tomichi Creek Reservoir	$25,936,000
Total Plan Construction Cost	$49,416,000
Interest During Construction (8% over three years)	$6,157,000
Total Plan Capital Cost	$55,573,000
Debt Service Reserve Fund (1 year debt service)	$5,507,000
Financing Expenses (1 1/2% of capital cost plus debt service reserve)	$916,000
Total Investment Cost	$61,996,000
ANNUAL COST :	
Annual Debt Service (8% over 30 years)	$5,507,000
Annual Lease and/or O&M Cost	$179,000
Total Annual Cost	$5,686,000

TABLE 13.16

Preliminary Cost Estimate - Alternative No. 6

INVESTMENT COST :	
Total Construction Cost of Recreation Components	$2,580,000
Total Construction Cost of Tomichi Creek Reservoir	$25,936,000
Total Plan Construction Cost	$28,516,000
Interest During Construction (8% over three years)	$3,553,000
Total Plan Capital Cost	$32,069,000
Debt Service Reserve Fund (1 year debt service)	$3,178,000
Financing Expenses (1 1/2% of capital cost plus debt service reserve)	$529,000
Total Investment Cost	$35,776,000
ANNUAL COST :	
Annual Debt Service (8% over 30 years)	$3,178,000
Annual Lease and/or O&M Cost	$120,000
Total Annual Cost	$3,298,000

Plan	Rank	Description
Alt. No. 5	1	Two reservoirs plus 10 recreation components
Alt. No. 6	3	One reservoir plus 10 recreation components
Alt. No. 1	2	Seventeen recreation components
Alt. No. 3	4	Three reservoirs plus 17 recreation components
Alt. No. 4	5	Three reservoirs plus 10 recreation components
Alt. No. 2	6	Three reservoirs

The result of the screening effort is that Alternative No. 5 is the preferred plan and Alternative No. 6 is the second place plan. The primary reason that Alternative No. 5 achieved the top rank position is because it meets more of the target objectives than any other plan. The reason that Alternative No. 1 was ranked third is because it can only meet one (recreation) of the three target objectives (recreation, irrigation supply, and M&I supply) associated with the study whereas Alternative No. 5 has the potential to meet all three to some significant degree.

After reviewing these results, the possibility of meeting agricultural shortages through non-structural measures was considered. Non-structural measures considered included water rights exchanges and purchase of agricultural land to leave more water in the stream. The most severe agricultural shortages identified in the No-Action Alternative occur in the upper areas of the sub-basins and therefore can not be satisfied through water rights exchanges and/or transfers. If the present study proceeds to a more detailed phase, the estimate of irrigation shortages should be refined and a drought leasing program whereby landowners in the upper basins would be compensated for not using their water during drought years should be considered. If this concept proves attractive, then the alternative plans should be reconsidered and Alternative No. 1 may become the preferred plan. The following presents a brief description of the preferred alternative and its potential benefits.

13.4.4 Preferred Alternative - Alternative No. 5

This alternative consists of two reservoirs located in the Upper Gunnison Basin (Ohio and Tomichi Creek Basins) and ten recreation components; one located in the Uncompahgre River Basin and the remaining nine in the Upper Gunnison Basin.

Scenario 1 (No Action Alternative) identified irrigation shortages in nine sub-basins in the study area. The two reservoirs proposed in this alternative will satisfy the two largest shortages identified. The hydrologic model results of this alternative indicate that the reservoirs will reduce the total average annual shortage in the Study Area by about 60 percent. Furthermore, the model results indicate that the reservoirs can provide releases to meet enhanced streamflow targets to benefit stream fishery habitat below each dam and will have reasonable reservoir fluctuations which would allow the development of a flatwater recreation facility at each site. Both reservoirs will provide some measure of flood control. Although Scenario 1 did not identify any M&I shortages in the study area, the water that is stored for the purpose of instream flow enhancement could possibly be stored under a transferred City of Gunnison storage decree for the combined purpose of municipal water storage and instream flow releases if the City should decide to convert its groundwater system to a surface water system in the future.

The ten recreation components cover a variety of activities including: fishery enhancement, boating, camping, hiking and bicycling. If implemented as a group, the following benefits are expected: national publicity, a significant increase in visitor days with associated economic benefits and a significantly enhanced recreational environment for the local population.

TABLE 13.17

Alternative Plan Comparison Table

Alternative Plan	Overall Ranking: Tech.	Envir.	Institutional/ Social	Cost[1]	Comments
1	Low	High	High	7.8 0.9 NA	Single purpose development plan benefits only recreation. Reliability of projected direct economic benefits is low to moderate at this stage of study therefore financing will be relatively difficult to obtain except for grants.
2	Low	Mod.	Mod.	83.2 7.5 137.0	Multipurpose development plan but benefits to recreation and flood control are relatively low, most of benefits are agricultural water supply. Includes three dams, one of which will have limited recreation benefit. Public resistance is expected to be severe.
3	Mod.	Mod.	Mod.	91.4 7.5 153.0	This plan combines alternatives 1 and 2. Weaknesses, except single purpose weakness, noted above exist in this plan also. Plan provides a relatively good balance of benefits.

[1] Cost shown are as follows: top number is total investment cost expressed in millions of dollars, second number is annualized investment cost also in millions, third number is unit cost of storage expressed in $/af.

TABLE 13.17 **(Continued)**

Alternative Plan Comparison Table

Alternative Plan	Overall Ranking: Tech.	Envir.	Institutional/ Social	Cost[1]	Comments
4	Mod.	Mod.	Mod.	86.4 7.9 144.0	This plan reduces the number of recreation components included in Alt. No. 3 but is the same otherwise. Some reduction of recreation benefit obviously results, but a good balance of benefits is still obtained.
5	High	Mod.	High	62.0 5.7 126.0	This plan includes all the recreation components of Alt. No. 4 but only two of the reservoirs. The reservoirs satisfy about 60% of identified irrigation shortages. Both reservoirs provide instream flow enhancement and both are potentially good flatwater recreation facilities because reservoir fluctuations are acceptable. This plan provides a good balance of potential benefits.

[1] Cost shown are as follows: top number is total investment cost expressed in millions of dollars, second number is annualized investment cost also in millions, third number is unit cost of storage expressed in $/af.

TABLE 13.17 **(Continued)**

Alternative Plan Comparison Table

Alternative Plan	Overall Ranking: Tech.	Envir.	Institutional/ Social	Cost[1]	Comments
6	Mod.	Mod.	Mod.	35.8 3.3 132.0	This plan includes all the recreation components of Alts. 4 and 5 but includes only one reservoir. The reservoir satisfies 40 percent of the identified irrigation shortage and provides streamflow enhancement and good flatwater recreation potential.

[1] Cost shown are as follows: top number is total investment cost expressed in millions of dollars, second number is annualized investment cost also in millions, third number is unit cost of storage expressed in $/af.

FIGURE 13.1

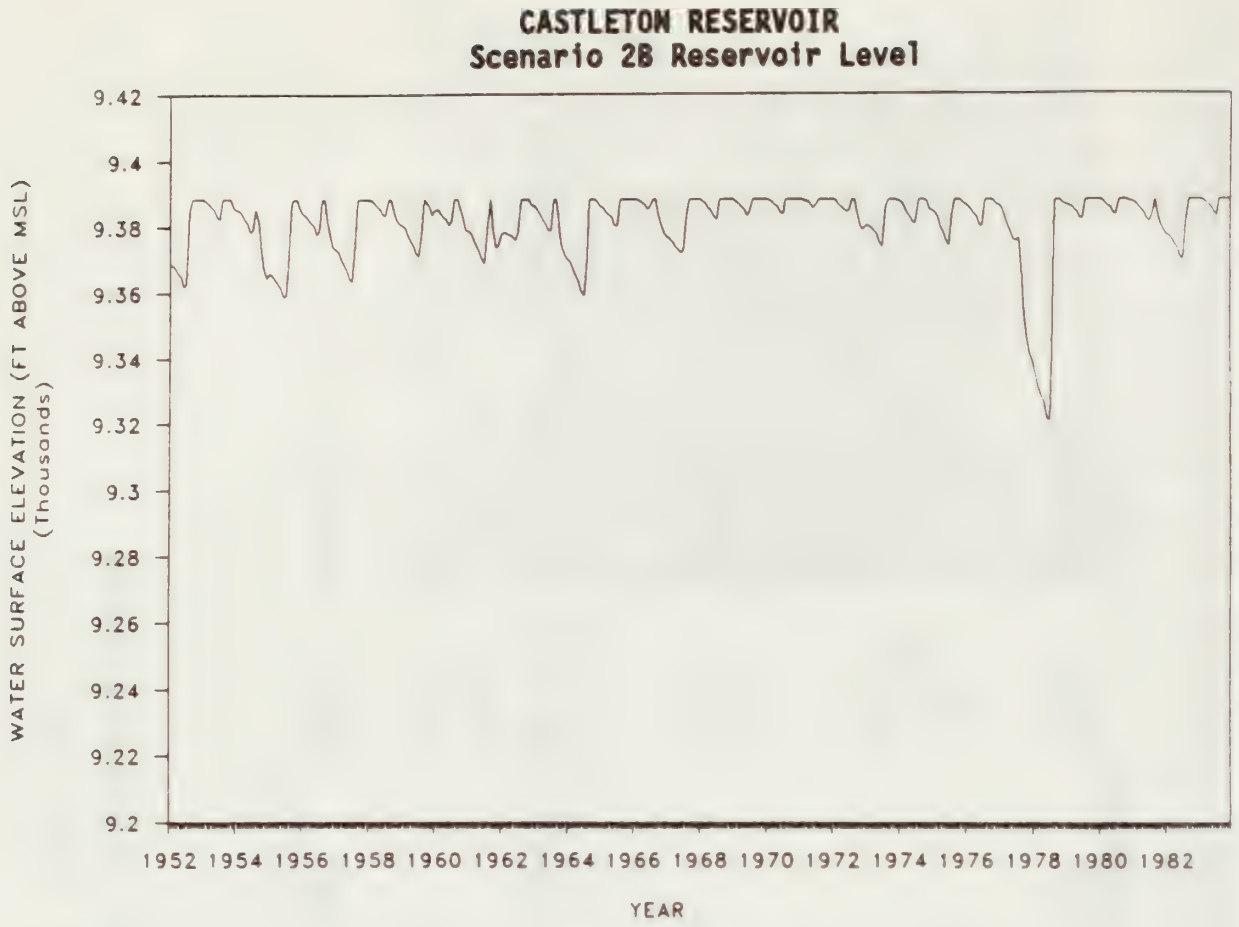


FIGURE 13.2

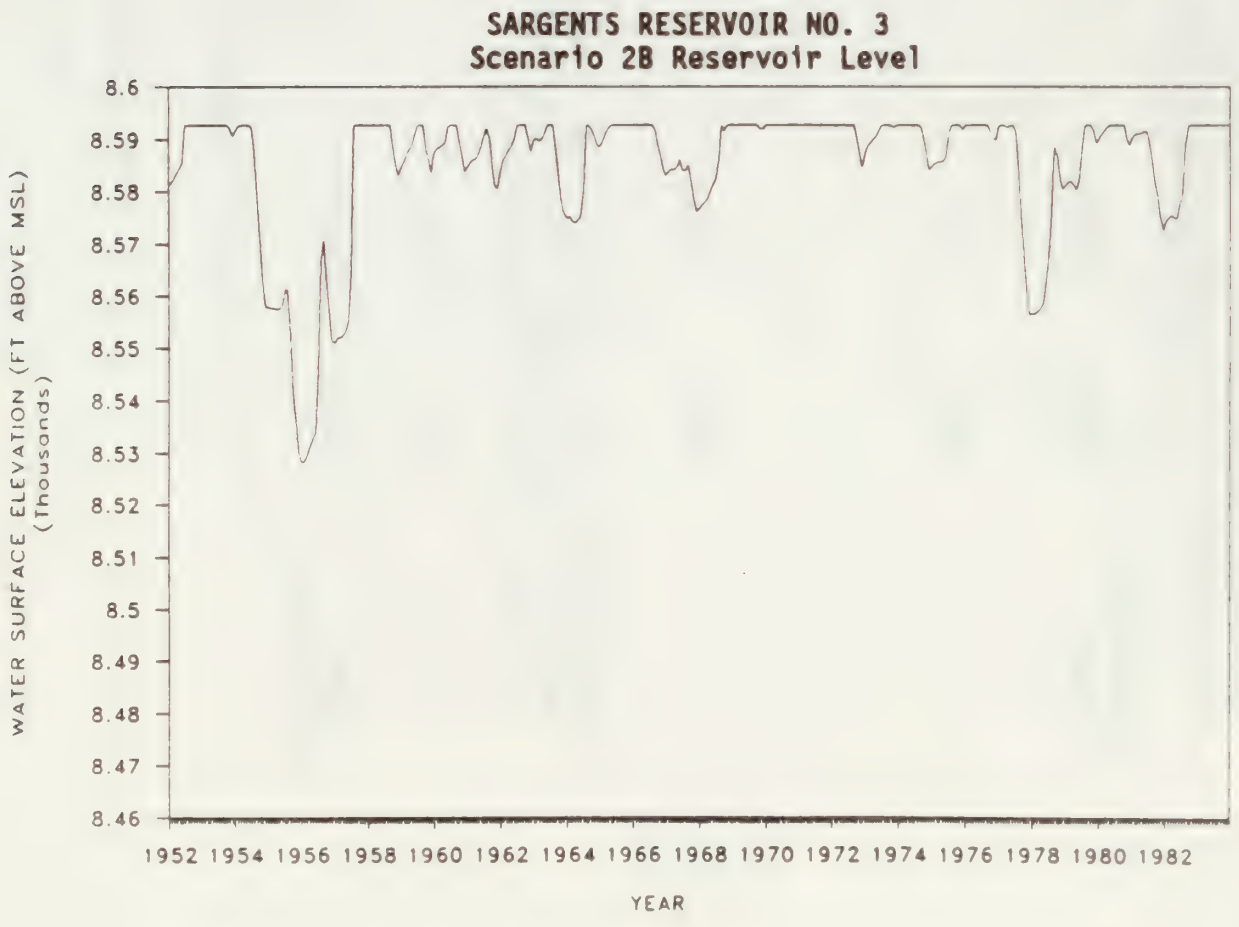


FIGURE 13.3

PAULINE RESEVOIR
Scenario 2B Reservoir Level

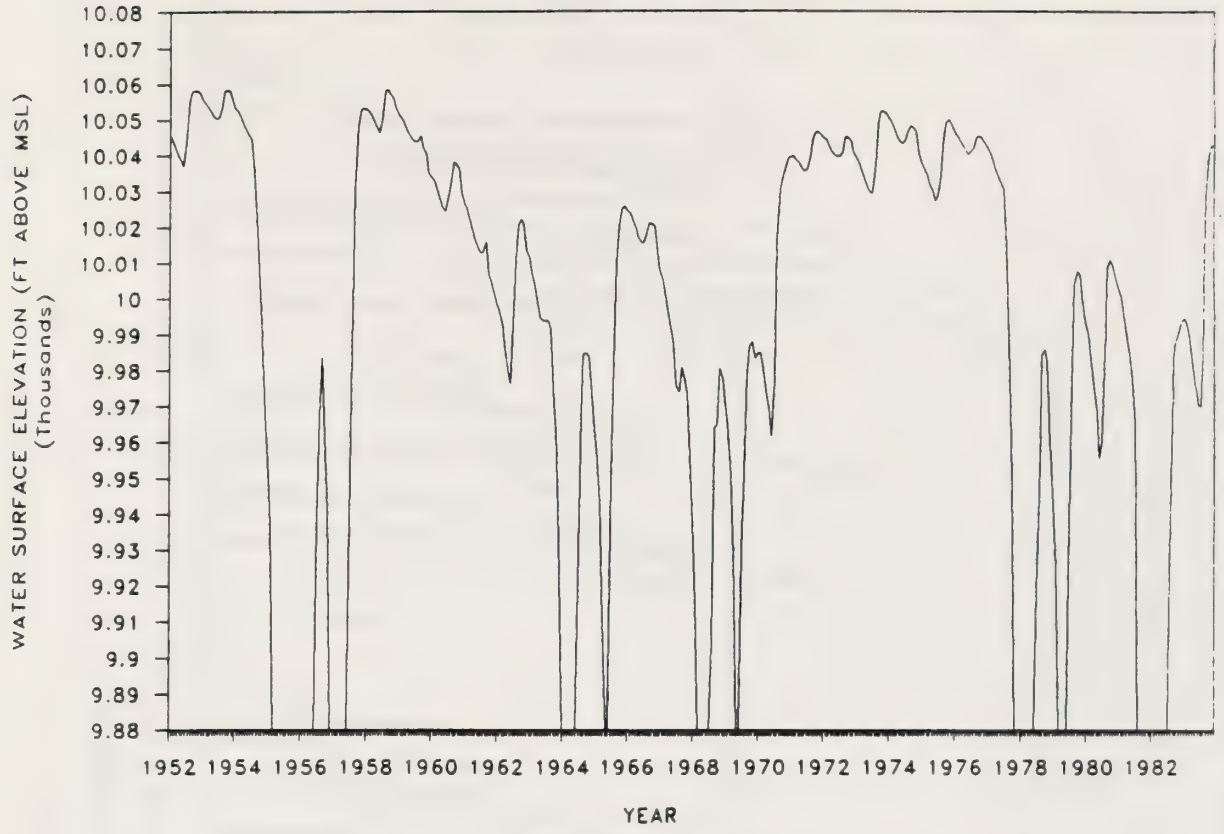


FIGURE 13.4

BLUE MESA RESERVOIR
Scenario 2B Reservoir Level

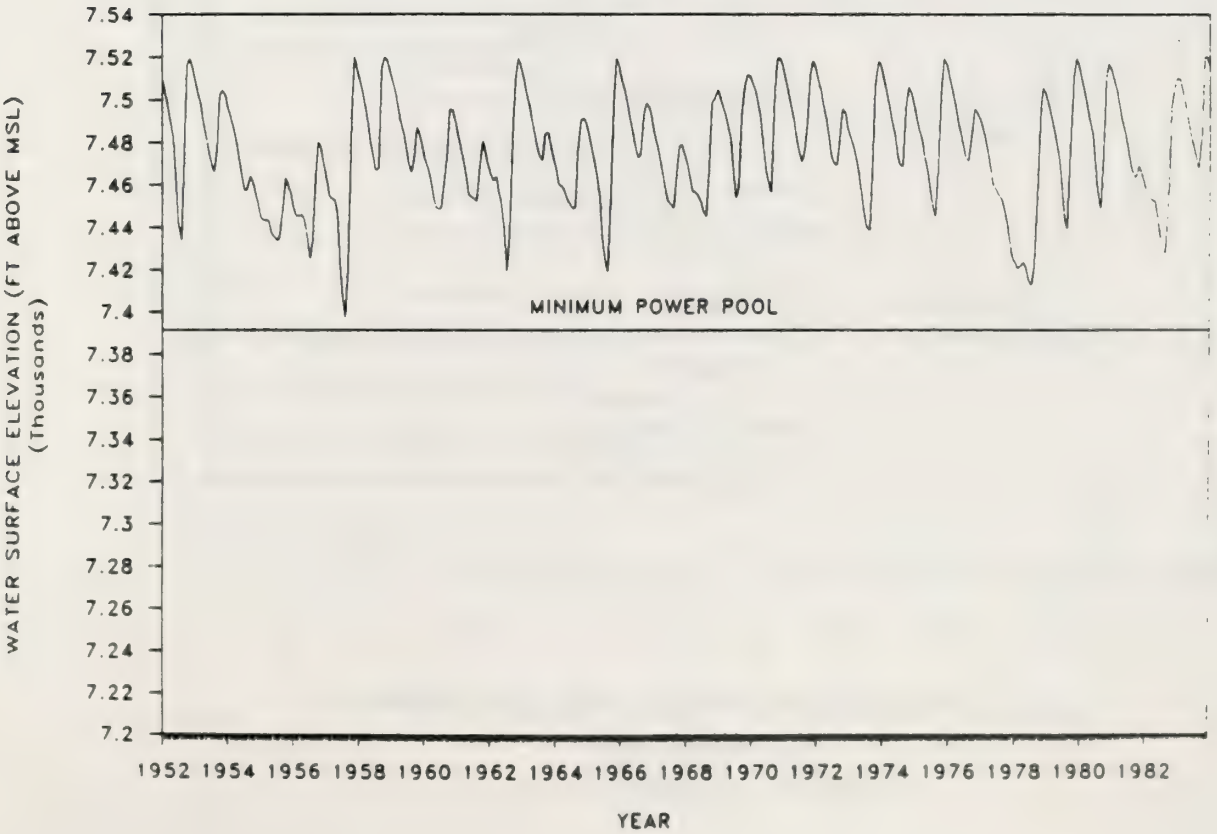


FIGURE 13.5

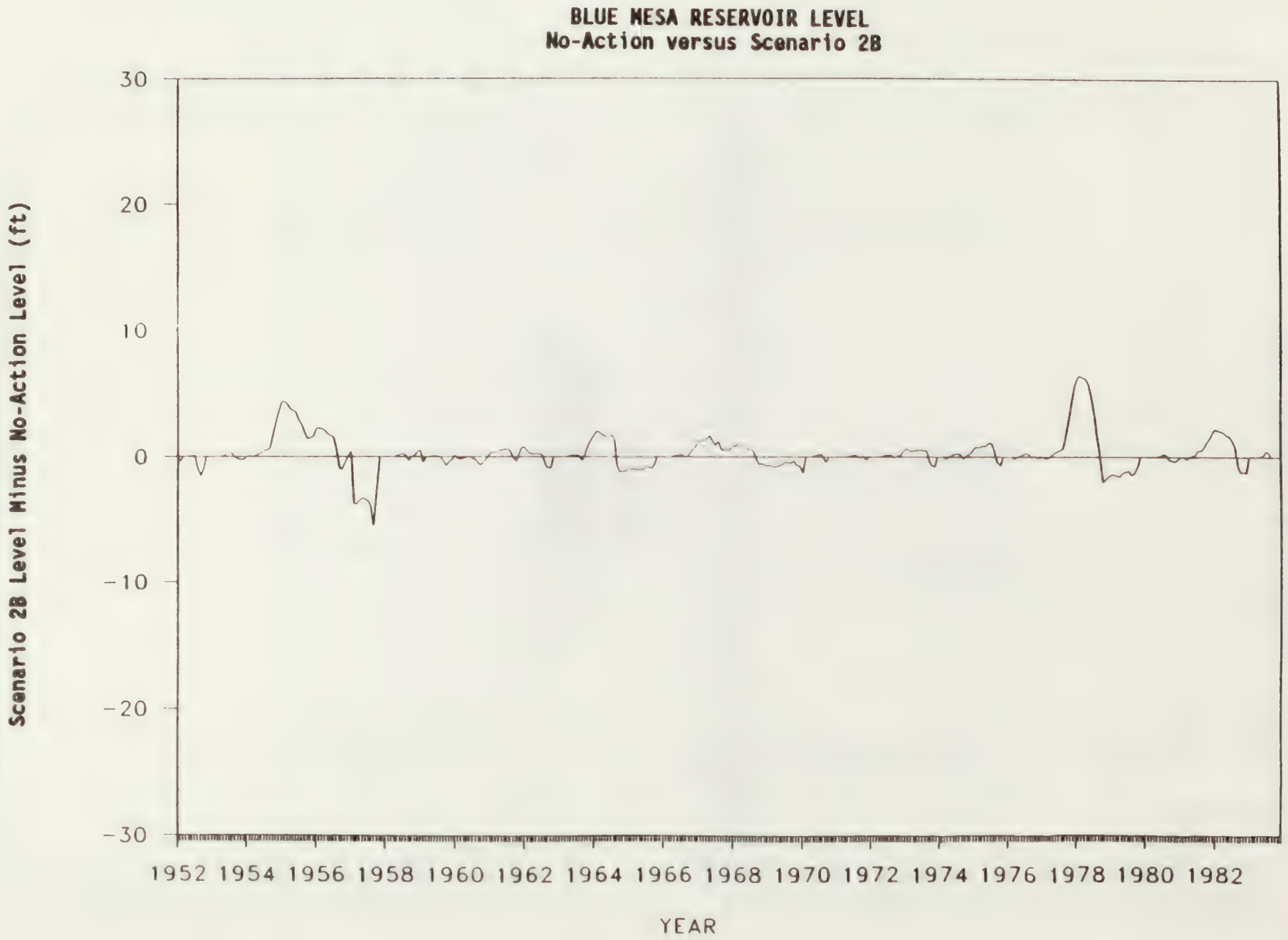
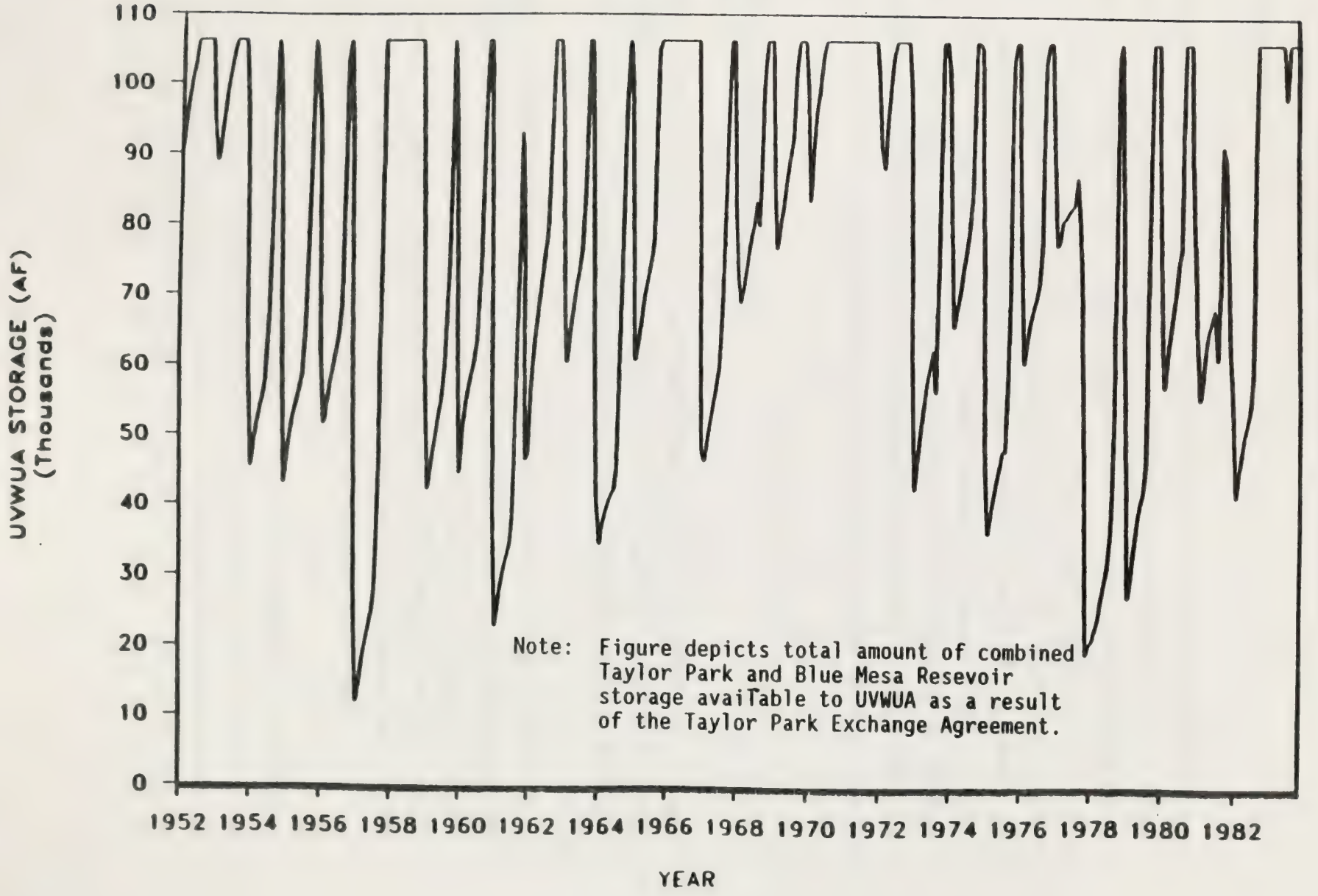

BLUE MESA RESERVOIR LEVEL
No-Action versus Scenario 2B
Scenario 2B Level Minus No-Action Level (ft)
30
20
10
0
-10
-20
-30
1952 1954 1956 1958 1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982
YEAR

FIGURE 13.6

TAYLOR PARK EXCHANGE
Scenario 2B



14.0 FINANCING OF PREFERRED ALTERNATIVE

14.1 INTRODUCTION

Considering that the primary beneficiaries of the alternative plans identified in this study are irrigated agriculture and recreation, it is clear that a mix of funding sources may be required to finance the preferred plan. An illustrative example of such a mix is the recent financing of the Stagecoach Project near Steamboat Springs, Colorado. This 33,000-acre-foot project is presently under construction and used a variety of financing and revenue sources. Financing sources included Authority revenue bonds, a CWCB loan, and a USBR Small Projects program grant and loan. Sources of revenue included hydroelectric power sales; water sales for industrial, municipal, and agricultural uses; and local conservancy district bond issues and ad valorem taxes.

14.2 POTENTIAL SOURCES OF REVENUE

Potential sources of revenue available for project repayment and payment of annual O&M costs depends to some degree on the specific plan considered. The potential sources of revenue are identified and discussed briefly below.

Sale of Irrigation Water. For plans which include storage reservoirs, a portion of the reservoir would be allocated to supply irrigation needs. The users who commit to purchase that water would be charged a fee for the amount of water allocated to irrigation. The charge for that water has not been studied in detail, however the ranchers' maximum ability to pay has been estimated to be on the order of $10 per acre foot.

Sales Taxes and/or Ad Valorem Taxes. Since the potential development will result in an economic benefit to the general public, it may be considered appropriate that a portion of the project repayment should be borne by the general public through the means of sales and/or ad valorem tax revenues.

Special District Tax. A special Economic Development and Recreation District might be created in the area which would have the power to establish and impose a sales tax and also to levy property taxes. Such an entity would require voter approval and passage of enabling legislation.

User Fees. User fees could be collected at campgrounds and from rafters. The rafting fee could be collected from raft operators who would include the amount in their trip price. Special fishing permits could also be considered, however such fees may result in turning visitors away.

Table 14.1 presents a summary table which indicates which of these potential sources of revenue could possibly be made available for each of the twenty components that are included in the six alternative plans.

14.3 POTENTIAL SOURCES OF FINANCING

Various potential sources of financing the alternative development plans exist. Some of these are grants while others are loans. Some can be applied toward certain components only while others can be used to finance the entire development, provided that the ability to repay can be demonstrated. The potential sources of financing are identified and briefly discussed below.

Revenue Bonds. If it can be demonstrated that the recommended alternative plan is financially feasible, revenue bonds could be issued to obtain the funds that can be supported by project revenues.

State Lottery Funds. A portion of the state lottery proceeds are transferred each year to the conservation trust fund to be made available in the form of grants to fund parks, trails and other recreation facilities which are available to the public free of charge. These funds are disbursed to counties, muncipalities, or special districts that have created a conservation trust fund. Applications for grants are considered on an individual basis. It is presently unclear whether all

of the recreational components included in the alternative plans would meet eligibility criteria for the funds. Resolution of that issue may have to await formal application for funds. Trails, parks and boat put-in and take-out points which do not collect a user fee are examples that would obviously qualify for funding. Obtaining these funds requires a long lead time as there are many competing applications and requires coordination and cooperation with local governmental entities.

CWCB Construction Loan. The Colorado Water Conservation Board has a construction loan fund which lends money for construction of water supply projects. These loans are provided at below-market interest rates (presently 5 percent) and may be a source of financing multipurpose storage reservoirs up to 50 percent of the project cost.

Fish and Wildlife Mitigation Grant. The State of Colorado enacted legislation (House Bill No. 1158) in 1987 which provides grants to water development project proponents to assist with the cost of implementing a mitigation program that is deemed necessary to protect the fish and wildlife resources of the state. This legislation requires the project proponent to bear the mitigation cost up to five percent of the project construction cost. The state will provide funds required above the proponents' five percent share. The maximum state grant is equal to five percent of the project construction cost.

USBR Small Projects Loan Program. The USBR provides loans, and grants for projects that include irrigation as a beneficiary. Loans for the cost of irrigation components of a project are interest free. This program was established under the provisions of the Small Reclamation Projects Act of 1956. Funds are available through this program for the development of new and improvement of existing projects. In order to qualify for these funds, the estimated total construction cost must be less than about $42 million. A project may be solely for irrigation or drainage purposes. It may also be a multi-purpose project which includes development of M&I water supply and treatment, hydroelectric power, flood

control, fish and wildlife enhancement, or outdoor recreation. The multipurpose reservoirs and rehabilitation of the irrigation diversions on the Gunnison River may qualify for these funds.

Aspinall Unit Mitigation Funds. The enabling legislation for construction of the Aspinall Unit of the Colorado River Storage Project provided a fund for fish and wildlife mitigation measures. A Fish and Wildlife plan was drawn up and most of the items in the plan have been accomplished. At this time, however, approximately $820,000 remains in the fund to acquire fishing easements, and fund wildlife developments on acquired big game range. This money has not been appropriated by Congress for disbursement but is owed to the state. It may be possible to negotiate an agreement between the USBR and the CDOW to obtain these remaining funds and use them to implement some of the recreation components.

Land Sales. The sale of property around the proposed Tomichi Creek Reservoir and/or collection of lease fees from landowners near the reservoir offers another potential source of funds for project development. The potential income from this source has not been quantified in this study and therefore was not considered in the financing strategy.

Table 14.2 presents a summary table indicating which of these potential sources of financing could possibly serve to finance each of the twenty components that are included in the six alternative plans.

Other potential sources of financing which were not considered in detail but which may be worthy of consideration in the future when project implementation is nearer at hand consist of:

- Local tax credits for landowners who provide access to their property.
- Federal tax credits for donation of property or access easements.

- Private-public cooperative financing agreements.

Although not considered as a source of financing in this phase of the study, another potential source of project funding that should be considered in future phases of this study is appropriated Federal funds. Such funds may be available for a project that is regional in nature such as an east-west slope cooperative development to provide water to a variety of users and also that would provide outdoor recreation opportunities.

14.4 POTENTIAL FOR STAGED CONSTRUCTION

Each of the six alternative plans fall into one of the following categories: a group of independent recreation components; a group of three independent storage reservoirs; or a combination of reservoirs plus recreation components. Although most of the individual components which comprise the six plans do not lend themselves to construction in successive stages, each of the alternative plans are well suited to staged development of components.

The preferred alternative, Alternative No. 5, can be constructed in stages in several different ways. In order to qualify for loan and/or grant money from the USBR Small Projects Loan Program, the overall project cost must be reduced to meet the $42 million project cost ceiling. Since this program is a very attractive source of potential project financing, it was assumed that the reservoir on Ohio Creek would be developed in a future phase and that Alternative No. 5, Phase I, would consist of a reservoir on Tomichi Creek and the ten recreation improvement components. The financial analysis discussed below relates to Alternative No. 5, Phase I, and does not address how the future phase might be financed.

14.5 FINANCIAL ANALYSIS OF PREFERRED PLAN

A preliminary financial analysis of the preferred plan was prepared in order to provide an indication of the financial viability of the preferred

plan. For the purpose of this study, a comparison was made of annual costs versus annual income for the first phase of the preferred plan.

14.5.1 Sources of Funding and Resulting Annual Costs

The broad list of potential funding sources available for project implementation presented in Table 14.2 was reviewed in an effort to identify sources considered to be most viable. After evaluating the list of potential sources, a financing strategy was developed which identified a potential source of funds for each component included in the plan. Table 14.3 defines the financing strategy used in the analysis.

The total amount of funding required to be derived from the sale of revenue bonds under this strategy is $2,851,000. The remainder of the required funding is assumed to come from various grants, or low interest state and Federal loans. Therefore, the only funds included in the financing strategy which require up front financing costs and interest during construction is the amount to be derived from the sale of revenue bonds. When interest during construction, debt service reserve funds and financing expenses are added to the construction amount allocated to revenue bonds, the total amount of bonds that are required is $3,635,000.

Table 14.4 presents a breakdown of required project funding by source along with the annual debt service associated with repayment of each source. The total annual cost associated with Alternative No. 5, Phase 1, based on the assumed financing strategy is $1,247,000.

It should be noted that the total annual cost can be reduced somewhat by eliminating the need for upfront financing costs of revenue bonds including interest during construction, debt service reserve funds, and financing expenses. This can be done by setting up a fund with relatively small annual payments into the fund during the permitting and final design phase of the project. Considering the lead time required to implement a project such as this, the project sponsors may be able to accumulate sufficient funds to cover

these up-front costs. If this were done, the total annual project cost could be reduced by about $70,000 to $1,177,000 per year.

14.5.2 Sources and Amount of Direct Project Income

The first phase of Alternative No. 5, if implemented, will generate direct income from the sale of agricultural water and from campground user fees. Other potential sources of direct project income are rafting fees, fisherman daily access fees and the sale of property in the vicinity of the proposed reservoir. These later sources require additional study to evaluate their viability and are not included in the analysis in order to take a conservative or worst case position at this early stage of the study. The average annual sale of agricultural water has been estimated to be 7800 af while annual campground use has been estimated at approximately 24,000 visitor days which equates to 8000 campsite-days based on historical figures of about three occupants per campsite. The resulting direct project income would be as follows:

7800 af per year of agricultural water at $10 per af	=	$78,000 per year
8000 campsite-days at $8.00	=	64,000 per year
Total		$142,000 per year

The direct agricultural benefits are the result of the $10 per af charge for the water. Quantifying increased agricultural production and including the market value of the incremental crops grown would constitute a double counting of the direct benefits and, therefore, has not been included in the Study.

14.5.3 Economic Benefits of Increased Tourism

The total increased visitation estimated to result from implementation of Alternative No. 5, Phase I is 62,000 visitor days. The economic impact to the

region resulting from this increased tourism was estimated using data available from various studies of tourist and visitor spending patterns throughout the United States. Based on the breakdown of expected visitation by the type of recreation components, the total estimated incremental visitor days was subdivided into 54 percent campers and 46 percent commercial lodgers. The estimate was prepared on the basis of direct expenditures and induced benefits. Direct expenditures represent spending by the additional visitors on all goods and services purchased in the area including food, beverages, retail shopping, supplies, lodging and other rentals, restaurant meals, gasoline and other transportation expenses that would accrue to the region. Induced benefits are represented by transactions among local businesses and spending resulting from local resident consumption, local government spending and other forms of local spending that will result from the increased visitation.

The estimate of total spending per visitor day used in the analysis is $24.60 for campers excluding campsite fees and $83.36 for commercial lodgers. The induced benefits associated with the direct visitor spending were estimated using the Colorado University, Center for Economic Analysis' (CUCEA) model of the Region 10 economy. The model estimates the induced benefits using estimated input-output linkages in the Region 10 economy, equations for local final demand spending and population impacts, estimated leakages of demand through imports to Region 10 of various goods and services not produced in the Region, and other key economic and demographic relationships. All key aspects of the methodologies utilized to make these estimates in the CUCEA's models have been peer reviewed in the economics profession and published in various professional economics journals. The estimated induced economic benefits are added to the direct impacts to produce an estimated total economic impact. These impacts are reported in terms of output (i.e., production) and employment resulting from the improved economy.

To generate the economic impacts reported herein, it was assumed that the additional visitor days associated with each alternative would be achieved by 1990; and the reported figures reflect the average impact level over the

remainder of the project planning horizon (1995-2034). Because of the dynamic nature of the CUCEA's models, the results were averaged starting in 1995 to allow for lagged effects contained in the model to reach a relatively stable level. The average results would not change significantly if the additional visitor days were assumed to begin in 1995 or 2000 and the average impacts computed for the 2000-2034 or 2005-2034 periods of time.

The results of this analysis are summarized as follows:

Direct Expenditures	$2,610,000
Induced Benefits	$1,840,000
Total Economic Output	$4,450,000
Direct Employment Generated	64
Total Employment Generated	94

14.5.4 Environmental Indirect Benefits

Implementation of the preferred alternative will result in other indirect benefits to the environment, fish and wildlife, and to the general public living in the area. No attempt has been made to quantify the economic impact of these indirect benefits; however, they are discussed briefly below.

Instream Flow. The preferred alternative includes one storage reservoir located in the Upper Tomichi Creek basin. This reservoir was sized to provide releases to enhance the natural streamflow in Tomichi Creek. For example, in the No-Action Alternative, minimum summer flows in Tomichi Creek above Razor Creek reach zero in six years of the 32-year period investigated whereas the minimum summer flow under Alternative No. 5, Phase 1, is 31 cfs as a result of the proposed storage reservoir on Upper Tomichi Creek. The expected flow regime in Tomichi Creek with the proposed reservoir in place is

expected to be highly beneficial to the existing fishery downstream of the proposed reservoir.

14.5.5 Flood Protection

A reservoir on Upper Tomichi Creek has the potential of providing flood protection to the Tomichi valley. The economics of constructing the reservoir large enough to do this has not been investigated in this phase of the study.

14.6 POTENTIAL SOURCES OF SUPPLEMENTAL INCOME

Section 14.5 demonstrated that direct project income is not sufficient for project debt repayment. However, the project also generates significant indirect benefits which would accrue to the general population of the study area. Potential sources of supplemental income for use in project debt repayment that were not included in the financing strategy were identified for consideration if the project sponsors believe that the indirect benefits warrant proceeding with project implementation. These potential sources are discussed below.

- o Formation of Special District. A special Recreation and Economic Development District could be formed in the study area for the purpose of providing economic development through the construction of water and recreation facilities. Such a district would require state legislative authorization and local voter approval. If such a district were formed for the entire study area and could levy a one mill property tax and a one-half cent sales tax, it is estimated that approximately $1,200,000 would be raised annually. If the district were formed to encompass the Upper Gunnison River Water Conservancy District (UGWCD) boundaries only, the annual tax income is estimated to be $550,000.

- o Increase UGRWCD Mill Levy. If the present UGRWCD mill levy were increased by one mill, it is estimated that approximately $170,000

additional per year would be raised. That money could possibly be used for the purpose of project debt service on the basis of the indirect benefit to the community at large.

- Water Sales. The UGRWCD or a newly created entity might be able to develop a water export project which may have the potential to subsidize the debt service associated with development of an in-basin development plan. This would be a significant undertaking for a local entity; however, they could implement such a project on a turnkey basis with a design-build team which would make it a manageable undertaking.

- Power Sales. The UGRWCD or a newly created entity might be able to develop a pumped-storage project that may have the potential to generate income in excess of its debt repayment that may have the potential to assist with debt service of an in-basin development.

- Aspinall Mitigation Funds. As described previously, $820,000 has been authorized but not appropriated for the purpose of obtaining access to stream fisheries in the Upper Gunnison Basin. It appears that a concerted effort by a coalition of the CDOW, local interests and Colorado's state and Federal political figures may be required to obtain these funds. If agreement were reached to use a portion of the funds for access to the East River and Tomichi Creek, the project annual cost would be reduced by $16,500.

- Land Sales. Depending on which reservoir site is selected for development, the sale of property adjacent to the reservoir and/or income from access leases may be a source of significant income. Construction of a reservoir in the Study Area may also lead to increased property values in the immediate area which would increase tax income to a special district such as described above.

TABLE 14.1

Potential Source of Revenue by Component

PLAN COMPONENT	POTENTIAL SOURCE OF REVENUE: Sale of Irrigation Water	Sales Taxes	Ad Valorem Taxes	Special District Tax	User Fees	
A 20,000af Storage Reservoir in the Ohio Creek Basin	*	*	*	*	*	
A 10,000af Storage Reservoir in the Upper Cochetopa Basin	*	*	*	*	*	
A 25,000af Storage Reservoir in the Upper Tomichi Basin	*	*	*	*	*	
Manage instream flows, improve access on public sections and improve irrigation diversions on Gunnison River to develop a trophy-size, wild rainbow trout fishery.		*	*	*		
Manage instream flows, institute special regulations and provide public access to 1/4 mile of stream below Taylor Park Dam to develop a trophy-size, wild rainbow trout fishery in the Upper below Taylor River.		*	*	*		
Study the potential for introducing large size trout in Blue Mesa Reservoir.		*	*	*		
Monitor conditions in the Uncompahgre River below Ridgway Dam to assess potential of developing a trout fishery.		*	*	*		
Provide public access to 3 miles of private property on the East River (short-term leases).		*	*	*		
Provide public access to 8 miles of private property on Tomichi Creek between Marshall Creek and the Gunnison River (short-term leases).		*	*	*		
Provide public access to 3 miles of private property on Quartz Creek. (short-term leases).		*	*	*		
Provide two raft and boat access points on the Taylor River.		*	*	*	*	
Modify selected stream reaches and manage Taylor Reservoir releases to improve Taylor River rafting during low flow periods.		*	*	*	*	
Provide three raft and boat access points on the Gunnison River.		*	*	*	*	
Develop 25 campsites on the Gunnison River below Almont.		*	*	*	*	
Develop 10 campsites and 18 miles of streamside trail on the East River between Almont and Crested Butte.		*	*	*	*	
Develop 25 campsites on the Taylor River.		*	*	*	*	
Develop 30 RV campsites at Taylor Park.		*	*	*	*	
Develop 4 miles of streamside trail along Tomichi Creek through the City of Gunnison including a 3-acre park and 20 picnic sites.		*	*	*		
Improve 32 existing primitive campsites along Cochetopa Creek within Cochetopa Canyon.		*	*	*	*	
Develop 17 miles of Uncompahgre River trail from Montrose to Ridgway Reservoir		*	*	*		

TABLE 14.2

Potential Source of Financing by Component

PLAN COMPONENT	POTENTIAL SOURCE OF FINANCING					
	State Lottery Funds	CWCB Construction Loan	USBR Small Projects Loan/Grant Program	Aspinall Unit Mitigation Funds	Sale of Lakefront Property	Revenue Bonds
A 20,000af Storage Reservoir in the Ohio Creek Basin		*	*		*	*
A 10,000af Storage Reservoir in the Upper Cochetopa Basin		*	*		*	*
A 25,000af Storage Reservoir in the Upper Tomichi Basin		*	*		*	*
Manage instream flows, improve access on public sections and improve irrigation diversions on Gunnison River to develop a trophy-size, wild rainbow trout fishery.			*	*		*
Manage instream flows, institute special regulations and provide public access to 1/4 mile of stream below Taylor Park Dam to develop a trophy-size, wild rainbow trout fishery in the Upper below Taylor River.				*		*
Study the potential for introducing large size trout in Blue Mesa Reservoir.				*		*
Monitor conditions in the Uncompahgre River below Ridgway Dam to assess potential of developing a trout fishery.				*		*
Provide public access to 3 miles of private property on the East River (short-term leases).				*		*
Provide public access to 8 miles of private property on Tomichi Creek between Marshall Creek and the Gunnison River (short-term leases).				*		*
Provide public access to 3 miles of private property on Quartz Creek. (short-term leases).				*		*
Provide two raft and boat access points on the Taylor River.	*					*
Modify selected stream reaches and manage Taylor Reservoir releases to improve Taylor River rafting during low flow periods.						*
Provide three raft and boat access points on the Gunnison River.	*					*
Develop 25 campsites on the Gunnison River below Almont.						*
Develop 10 campsites and 18 miles of streamside trail on the East River between Almont and Crested Butte.	*					*
Develop 25 campsites on the Taylor River.						*
Develop 30 RV campsites at Taylor Park.						*
Develop 4 miles of streamside trail along Tomichi Creek through the City of Gunnison including a 3-acre park and 20 picnic sites.	*					*
Improve 32 existing primitive campsites along Cochetopa Creek within Cochetopa Canyon.						*
Develop 17 miles of Uncompahgre River trail from Montrose to Ridgway Reservoir.	*					*

TABLE 14.3

Financing Strategy for Alternative No. 5, Phase I

Plan Component	Construction Cost ($)	Annual Cost ($)	Funding Service
Gunnison River Trophy Fishery	150,000		CWCB [1] Construction Loan
		3,000	Project Income or Taxes
Taylor River Trophy Fishery	25,000		DOW
		6,000	Project Income or Taxes
Gunnison River Boat Access	90,000		State Lottery Funds
		3,000	Project Income or Taxes
Taylor River Campgrounds	250,000		Revenue Bonds
		5,000	User Fees
Cochetopa Creek Campgrounds	215,000		Revenue Bonds
		6,500	User Fees
Uncompahgre River Trail	1,700,000		State Lottery ($500,000) Funds and Revenue Bonds ($1,200,000)
		17,000	Project Income or Taxes
Tomichi Creek Reservoir	25,936,000		USBR[2] grant ($5,000,000) and Loan ($8,500,000); CWCB Loan ($10,000,000); State Environmental Mitigation Funds ($1,250,000) Revenue Bonds ($1,186,000)
		63,000	Project Income or Taxes
Taylor Riverbed Mod. for Rafting	150,000	-	State Lottery Funds
East River Access	-	4,500	Project Income or Taxes
Tomichi Creek Access	-	12,000	Project Income or Taxes
TOTAL	$28,516,000	$120,000	

[1] Colorado Water Conservation Board.

[2] USBR grant and loan refers to funds available under the Small Reclamation Projects Act of 1956.

TABLE 14.4

Breakdown of Total Annual Cost
Alternative No. 5, Phase 1

Funding Source	Amount	Annual Debt Service
DOW Grant	$ 25,000	-
USBR Grant (Small Projects Loan Program)	5,000,000	-
Lottery Funds Grant	740,000	-
State Envir. Mitigation Funds (grant)	1,250,000	-
USBR Loan (0 int. over 40 years)	8,500,000	$ 212,500
CWCB Loan (5% int. over 40 years	10,150,000	591,540
Revenue Bonds (8% over 30 years)	3,635,000	322,985
Total Annual Debt Service		$1,127,025
Annual Lease, O&M Cost		120,000
Total Annual Cost		$1,247,025

15.0 POTENTIAL FINANCIAL ENHANCEMENT

15.1 INTRODUCTION

Potential projects were identified and evaluated which, when combined with the preferred in-basin development plan, might result in a more comprehensive project with enhanced financial feasibility. The previous chapter indicated the need to improve the financial feasibility of the preferred plan and two options were considered; the sale of peaking power produced by a pumped-storage project; and the sale of water out of the study area. These options may require participation from electrical power entities or east slope water suppliers. This study has not speculated on the specific institutional relationships that might be involved. If these entities pursue a cooperative approach to project development, further study would be required to arrive at an equitable sharing of project costs and benefits.

15.2 PUMPED-STORAGE HYDROELECTRIC POWER GENERATION

The term "pumped-storage" as utilized herein refers to a hydroelectric generating facility utilizing pumping equipment to store energy for use at a later time. Such developments involve pumping water from a lower reservoir to an upper reservoir with low cost off-peak power and later releasing the water from the upper reservoir back to the lower reservoir during peak power demand periods to generate high value peaking power. Reversible pump-turbines are typically used to perform the functions of pumping and generating electricity. Pumped-storage projects do not consume water; rather they recirculate the same water and after initial reservoir filling only require additions to the water supply to make up for evaporation and seepage losses.

15.2.1 Planning Criteria

The most efficient pumped-storage sites have a large elevation difference (head) and a short water conductor length between the upper and lower reservoirs. A common rule of thumb states that the ratio of water conductor

length to head should not exceed a value of about 10 for high head plants such as were considered in this study. This criteria was adopted for the present study and potential projects with ratios greater than 10 were not considered.

Existing pumped-storage projects in the United States operate on either a daily or weekly cycle. At daily cycle plants, the storage required for each day's generation is replenished by pumping during the following night. In the case of weekly cycle plants, sufficient storage capacity is provided to permit a portion of the pumping to be accomplished on weekends. Daily cycle operation is usually only used when the required generating cycle is 4 to 6 hours per day at full capacity. Utilities in Colorado presently desire peaking power plants which have the ability to generate at full load for ten to twelve hours per weekday, five days per week. This is based on the fact that the peak period of consumption of electricity has gotten longer over the years. Therefore, for the purpose of this study, a weekly cycle operation was used.

The reservoir volume requirements were determined assuming that the pumped-storage project would generate power for a ten-hour period each day of the week (excluding weekends), and that water would be pumped from the lower reservoir to the upper reservoir for a ten-hour period each night of the week and up to twenty hours during the weekend.

Cycle efficiency accounts for all losses in the operating cycle except for transmission losses. This value includes water passage head losses as well as pump, turbine, motor, generator, and transformer losses. Based on past experience with pumped-storage projects, cycle efficiencies range from 66 percent to 78 percent. A cycling efficiency of 70 percent was adopted for this study.

The charge to discharge ratio for a pumped-storage unit is the ratio of the average load in megawatts to the unit's rated capacity. Ratios for existing plants typically fall in the range from 0.9 to 1.4 The average

charge to discharge ratio for existing U.S. plants is about 1.1 and that value was adopted for use in this study.

These criteria are summarized as follows:

Parameter	Value
Generating period	10 hours per day
Pumping period	10 hours per day
Cycling period	Weekly
Generating efficiency	83 percent
Overall cycle efficiency	70 percent
Charge/discharge ratio	1.1

15.2.2 Identification of Alternative Sites

Identification of potential pumped-storage sites within the study area was carried out by performing a review of readily available literature which relates to previously identified projects and by performing a prefeasibility level map study. The results of the identification effort are presented in Figure 15.1 which indicates the location of all potential pumped-storage sites considered in this study. Although site identification was carried out without regard to installed capacity, the number of sites identified with a large potential installed capacity led to the decision to eliminate sites smaller than 300 MW in order to maximize potential benefits.

As discussed previously, three potential in-basin reservoir sites were identified for possible inclusion in alternative plans. These sites were reviewed for the possibility of adding a pumped-storage component which would utilize the proposed reservoir as the lower reservoir. The proposed site on Ohio Creek was eliminated because topographic conditions are not suitable. Topography in the area of the two Upper Cochetopa sites would support a relatively small project (less than 300 MW) and therefore were dropped from further consideration. Several reasonable sites exist along Upper Tomichi

Creek for a moderate sized installation (300 to 600 MW) depending on the site finally selected for an in-basin reservoir in that area. From the environmental standpoint, the proposed in-basin reservoirs are small in size and a pumped-storage development associated with any of the sites would result in daily water level fluctuations that would be detrimental to recreation, one of the primary purposes of the reservoirs. Since a number of much better sites appear to be available in the study area, pumped-storage at any of the proposed in-basin reservoir sites was dismissed from further consideration.

15.2.3 Screening of Sites

Past experience has demonstrated that the best indicator of the economic feasibility of a potential high head pumped-storage project is the ratio of the length of the water conductor to the available head (L/H). It was decided therefore to screen and rank the alternative projects based on that ratio. The exception to this is the potential Curecanti project which does not require any new reservoir construction. This project was evaluated on technical, environmental and institutional factors.

The results of ranking sites according to the L/H ratio are presented in Table 15.1. This table indicates that the most attractive sites within the study area are those which utilize existing USBR reservoirs for the lower reservoir.

15.2.4 Evaluation of Sites

In order to make a preliminary assessment of whether pumped-storage could provide a reasonable source of revenue for enhancing the financial feasibility of in-basin development, it was decided to perform an appraisal level evaluation of a limited number of representative potential projects.

TABLE 15.1

Pumped Storage Sites Considered

Map ID No.	Project Name	UPPER RESERVOIR Name	Volume, ac.ft.	Type (1)	Height ft.	LOWER RESERVOIR Name	Volume, ac.ft.	Type (1)	Height ft.	Gross Head ft.	Installed Capacity L/N	Installed Capacity MW	REMARKS
20	Sheep Knob	Sheep Knob	4,000	ring	100	Crystal Res.	13,000	exst	320	2,600	2.5	460	Eliminate Due to Lower Reservoir Fluctuation
24	Needle Pt. No.3	Highway 92	8,500	ring	120	Morrow Pt. Res.	42,000	exst	470	1,920	3.6	720	
2	Brush Creek	Teocalli Ridge	1,377	ring	80	Brush Creek	3,700	conv	80	1,360	3.6	80	Eliminate Based on Capacity
15	Horse Mesa	Horse Mesa	10,000	ring	80	Big Blue Ck.	15,000	conv	240	880	3.9	390	
5	Rocky Point No.1 (2)	Rocky Point	3,900	ring	120	Taylor Park Res.	106,000	exst	200	2,350	4.1	410	
6	Rocky Point No.2 (3)	Rocky Point	10,000	ring	130	Taylor Park Res.	106,000	exst	200	2,350	4.1	1,040	
22	Morrow Point No.2	Corral Gulch	7,700	conv	160	Morrow Pt. Res.	42,000	exst	470	2,080	4.1	710	
11	Cebolla Creek No.1	Dry Lake Ridge	5,500	ring	80	Spring Ck.	8,500	conv	150	720	4.3	180	Eliminate Based on Capacity
1	Oh-Be-Joyful	Lower Peeler Lakes	4,750	ring	130	Creek below Lakes	7,400	conv	160	1,040	4.6	220	Eliminate Based on Capacity
7	Pitkin	Quartz Dome	2,300	ring	80	Roosev't Picnic Area	11,000	conv	200	1,880	4.7	190	Eliminate Based on Capacity
3	Cement Creek No.2	Point Lookout	2,200	ring	80	Near Guard Station	9,000	conv	160	2,120	4.9	210	Eliminate Based on Capacity
18	Halfway House No.2	Fitzpatrick Mesa	7,900	ring	80	Halfway House	15,000	conv	200	920	5.0	320	
30	Curecanti	Blue Mesa Res.	7,000	exst	390	Morrow Pt. Res.	42,000	exst	470	310	5.2	100	Eliminate Based on Capacity
16	Silver Jack	High Mesa	8,000	ring	100	Silver Jack Res.	12,800	exst	170	2,210	5.4	780	
14	Lake Fork No.2	Alpine Plateau	6,800	ring	100	Soldier Ck.	10,000	conv	210	880	5.6	270	Eliminate Based on Capacity
8	Marshall Creek	Peak	5,500	ring	80	Marshall Ck.	8,300	conv	180	1,840	5.9	450	
12	Cebolla Creek No.2	E. Fish Canyon Ridge	11,000	ring	100	Cebolla Ck.	16,500	conv	110	1,880	6.1	920	
25	Curecanti Creek	Johnson Gulch	5,500	conv	120	Morrow Pt. Res.	42,000	exst	470	2,080	6.3	510	
9	Needle Creek	Big Hill	5,100	ring	150	Needle Ck. Res.	7,500	exim	160	1,000	6.4	230	Eliminate Based on Capacity
13	Lake Fork No.1	Cherry Ck.	2,000	conv	80	Cherry Ck. Spring	3,700	conv	80	800	6.6	70	Eliminate Based on Capacity
19	Needle Pt. No.1	Round Corral Ck.	7,500	conv	200	Morrow Pt. Res.	42,000	exst	470	1,440	6.9	480	
10	Cathedrel Creek	Cathedrel Pack Trail	9,000	ring	80	Cath. & Spring Ck.	13,500	conv	140	1,320	7.0	530	
21	Morrow Point No.1	Mesa Creek	4,500	conv	400	Morrow Pt. Res.	42,000	exst	470	1,100	7.1	220	Eliminate Based on Capacity
26	Soap Mesa	Soap Mesa	6,500	ring	60	Blue Mesa Res.	825,900	exst	390	720	7.2	210	Eliminate Based on Capacity
23	Needle Pt. No.2	Myers Gulch	10,000	ring	320	Morrow Pt. Res.	42,000	exst	470	1,720	7.5	760	
28	Carpenter Ridge	Carpenter Ridge	7,000	ring	80	Blue Mesa Res.	825,900	exst	390	1,200	7.7	370	
17	Halfway House No.1	Blue Mesa	5,000	ring	100	Halfway House	15,000	conv	200	560	8.2	120	Eliminate Based on Capacity
4	Cement Creek No.1	Ridge abv. Creek	3,700	conv	240	Hot Spring	10,750	conv	80	880	9.2	140	Eliminate Based on Capacity
29	Willow Creek	Willow Creek	9,000	ring	60	Blue Mesa Res.	825,900	exst	390	1,180	9.5	470	
27	Dry Gulch	Dry Gulch	5,500	ring	100	Blue Mesa Res.	825,900	exst	390	1,080	9.8	260	Eliminate Based on Capacity

Notes:

(1) Conv. - conventional dam on natural stream
Ring - ring dike construction
Exst - Existing dam
Exim - Existing dam with improvements

(2) Data taken from NECO FERC Licence Application with installed capacity adjusted to meet present study criteria.

(3) Project as proposed by NECO but with expanded upper resevoir.

(4) Amount required for power generation.

The Curecanti project was noted as an attractive site because no new reservoir construction is required. Instead, it utilizes the existing Blue Mesa and Morrow Point reservoirs for its upper and lower reservoirs, respectively. Additionally, this project appears to have a favorable length to head ratio. Evaluation of this project showed that the amount of daily fluctuations of Morrow Point reservoir appears to be acceptable for an installed capacity of about 50 MW or less (5 ft). The fluctuation is marginally acceptable at a capacity of 100 MW (9 ft) and definitely unacceptable at capacities greater than about 150 MW (15 ft). Because of the relatively small potential capacity of the project and the potential adverse impacts of fluctuation in Morrow Point Reservoir levels, this project was eliminated from further consideration in this study.

The top ranked site, Sheep Knob was eliminated because of excessive lower reservoir fluctuation. Development of Sheep Knob would cause relatively severe water level fluctuations in Crystal Reservoir due to the small storage volume of that reservoir (17,600 af). Crystal presently operates at a relatively constant level in order to maximize power generation. The amount of power generated at the Crystal power plant would be reduced significantly if Sheep Knob were developed. For the purpose of this study therefore, Sheep Knob was dropped from consideration in favor of the second ranked project, Needle Point No. 3. Since the Rocky Point project was ranked number three and since feasibility level cost estimates are available for that project, it was decided to also include that project in the evaluation.

Before a detailed financial analysis of a hydroelectric project can be made, it is necessary to identify the power purchasers and the characteristics of their respective loads, and to define the time of project completion in order to arrive at the value of the power that will be produced. This is especially important in the case of a pumped-storage project which uses off peak power and generates peaking power.

Preliminary results of a statewide peaking power study which was recently completed for the Authority indicates that between 75 and 825 MW of

pumped-storage capacity could be absorbed within Colorado by the year 2007, depending on demand growth assumptions. The study also concluded that a pumped-storage project which can be constructed for $1000 to $1200 per installed kilowatt (based on investment cost) may be attractive to utilities. It was decided to evaluate the two projects identified herein on the basis of project investment cost per installed kilowatt and compare them to these figures. The results of the comparison will indicate if pumped-storage is indeed a reasonable financing mechanism and therefore worthy of further consideration in future phases of this study, if any are undertaken.

15.2.5 Needle Point No. 3 Project Evaluation

This project is located on the north side of Morrow Point reservoir and about one mile west of Curecanti Creek. It has an average gross head of about 1930 feet which can support an installed capacity of 720 MW.

The project consists of the following features: an upper reservoir located on a knob between Myers Gulch and Curecanti Creek; a water conductor consisting of a vertical pressure shaft and a low-level, high pressure power tunnel; and underground powerhouse; a low-pressure tailrace tunnel; a surge chamber; an access shaft and tunnel; and a separate cable tunnel which can also serve as an emergency exit. The project utilizes the existing Morrow Point reservoir for the lower reservoir. The general project configuration is shown on Figure 15.2. The use of a underground powerhouse, access shaft and cable tunnel shaft were dictated by the steep canyon and the existence of Morrow Point reservoir. The pressure tunnel was sized based on flow requirements and a maximum velocity of 20 feet per second.

For preliminary cost estimating purposes, the powerhouse was assumed to consist of three 240 MW pump-turbine units. It was also assumed that approximately 1500 feet of steel tunnel lining would be required upstream of the powerhouse.

The preliminary cost estimate for the Needle Point No. 3 pumped-storage project is summarized in Table 15.2. The total capital cost of the project is approximately $577 million. This results in a unit cost of about $800 per installed kilowatt.

15.2.6 Rocky Point Project

The Rocky Point pumped-storage project is located on the north side of Taylor Park Reservoir and utilizes that existing reservoir as the lower reservoir of the proposed pumped-storage project. As presently proposed by NECO, this project has an installed capacity of 1000 MW computed on the basis of generating power about eight hours per day, five days per week. In order to put this project on the same basis as all the other projects considered, it was necessary to increase the size of the upper reservoir to provide sufficient storage to generate power 10 hours per day, five days per week.

The project consists of the following features: an upper reservoir located on a high knob near Matchless Mountain approximately two miles northwest of Taylor Park dam; a water conductor consisting of a vertical shaft, inclined tunnel and horizontal tunnel; an underground powerhouse; a low pressure tailrace tunnel and a surge chamber. The general project configuration is shown on Figure 15.3. The powerhouse includes four 250 MW units.

The preliminary cost estimate for the Rocky Point pumped-storage project is presented in Table 15.3. The estimate is the same estimate presented in NECO's FERC license application with a modification to the upper reservoir cost. The estimate has also been updated to the January 1989 price level and financing costs have been included. The total capital cost for this project is $919 million. This results in a unit cost of about $920 per installed kilowatt.

TABLE 15.2

Preliminary Cost Estimate
Needle Point No. 3 Pumped-Storage Project

Project Feature	Cost
Structure and Improvements:	
Powerhouse Civil Works	$ 40,000,000
Powerhouse Access (Road and Shaft)	15,000,000
Cable Tunnel/Shaft	10,000,000
Land Acquisition	1,000,000
Reservoir, Dam and Water Conductors:	
Upper Dam and Appurtenant Structures	65,000,000
Tunnels, Shafts, Surge Chamber and Steel Liner	61,000,000
Upper and Lower Reservoir Intake Structures	15,000,000
Turbines and Generators	55,000,000
Accessory Electrical Equipment	8,000,000
Miscellaneous Mechanical Equipment	5,000,000
Station Service Equipment	18,000,000
Transmission Line	20,000,000
Miscellaneous Items (5%)	16,000,000
Subtotal - Direct Cost	329,000,000
Contingencies (25%)	82,000,000
Total Direct Cost	411,000,000
Engineering and Administration (15%)	62,000,000
Total Construction Cost	473,000,000
Interest During Construction (8% over 5 years).	104,000,000
Total Capital Cost	577,000,000
Debt Service Reserve Fund	57,190,000
Financing Expenses	9,660,000
Total Investment Cost	$643,850,000

UNIT CAPITAL COST = $801/KW

TABLE 15.3

Preliminary Cost Estimate
Rocky Point Pumped-Storage Project

Project Feature	Cost
Structures and Improvements:	
Powerhouse Civil Works	$ 61,400,000
Powerhouse Access Tunnel	12,600,000
Cable Tunnel	10,700,000
Access Roads	8,400,000
Reservoir Dam and Water Conductors	
Upper Dam and Appurtenant Structures	65,000,000
Tunnels, Shaft, Surge Chamber and Steel Liner	143,400,000
Taylor Park Reservoir Multilevel Outlet and Improvements	20,100,000
Turbines, Generators and Auxiliary Equipment	87,400,000
Accessory Electrical Equipment	13,200,000
Transformers, Switchgear and Miscellaneous	27,100,000
Station Service Equipment	9,600,000
Switchyard and Transmission Line	45,200,000
Subtotal - Direct Cost	504,100,000
Contingencies (25%)	126,000,000
Total Direct Cost	630,100,000
Engineering and Administration (15%)	94,500,000
Total Construction Cost (1 Jan 1987 Price Level)	724,600,000
Total Construction Cost (1 Jan 1989 Price Level)	754,000,000
Interest During Construction (8% over 5 years)	165,000,000
Total Capital Cost	919,000,000
Debt Service Reserve Fund	91,100,000
Financing Expenses	15,400,000
Total Investment Cost	$1,025,500,000

UNIT CAPITAL COST = $919/KW

15.2.7 Conclusion

The study area contains a number of potential pumped-storage sites. One of the 30 sites identified, Needle Point No. 3, was evaluated to a prefeasibility level of detail. One other project, Rocky Point No. 2, was previously studied to full feasibility level by the project proponent and the project layout and cost estimate from that study was used with one minor modification. The cost per installed capacity for either project is less than the cost that reportedly may be attractive to utilities in Colorado. A comparison of project costs with the attractive cost range is shown below:

Project	Estimated Unit Cost ($/KW)	Attractive Range of Unit Cost ($/KW)
Needle Point No. 3	800	1000 to 1200
Rocky Point No. 2	920	1000 to 1200

It should be noted that these two projects have been studied to different levels of detail. The Needle Point No. 3 project has been studied to a very preliminary level while Rocky Point has been studied to full feasibility level. Therefore, a comparison of the two projects based on the cost figures presented above may not be entirely valid.

It appears that a pumped-storage project in the study area may be financially feasible and could possibly serve to enhance the financial feasibility of an in-basin water resource development plan if combined with that plan.

15.3 OUT-OF-BASIN WATER SALES

The possibility of exporting water from the study area to the Front Range was investigated as a potential method of enhancing the financial feasibility of an in-basin development plan. The purpose of the investigation was to

determine if the potential for an export project exists; and if so, to make a preliminary determination as to whether such a project appears to be financially feasible and therefore would warrant further, more detailed study. Water sales to downstream states was not investigated due to institutional constraints associated with such an arrangement.

A review of existing data and reports identified three previously studied projects which would divert water from the Upper Taylor River basin to either the Arkansas River basin or the South Platte River basin. These projects are:

- the Collegiate Range Project as proposed by the City of Aurora;
- the Union Park Water Supply Project as proposed by Arapahoe County; and
- the Central Colorado Project as evaluated by the Central Colorado Water Conservancy District.

In addition, the concept of diverting Upper Taylor River water from the existing Taylor Park Reservoir to either the Arkansas or South Platte Basins was evaluated (Taylor Park Project). These four potential projects are illustrated schematically in Figure 15.4.

15.3.1 Methodology

The methodology and simplifying assumptions which formed the basis of this investigation are as follows:

- In cases where the export projects affect the operation of existing facilities, require purchases of Blue Mesa Reservoir water to replace water diverted upstream, or involve contractual arrangements with holders of senior water rights, it was assumed that the necessary agreements could be reached. Legal and institutional constraints associated with purchases of Blue Mesa Reservoir water are discussed in Section 10.4.1. Other constraints are discussed in

the context of the specific export projects in the remainder of this chapter.

- The project configurations reported in published literature for previously studied projects were accepted. In the case of the Collegiate Range Project, the project proponent has stated that additional front range storage is not a required element of the project (personal communication with Mr. Doug Kemper, Manager of Water Resources).

- Independent cost estimates were developed for each project. The methodology used in preparing the cost estimates are discussed in Section 12.8 and in Appendix F.

- Preliminary engineering studies were carried out for new projects in order to size the project features and to estimate construction quantities for use in preparing cost estimates.

- Front range storage requirements to accommodate the Taylor Park Project water deliveries were estimated based on a uniform inflow rate to a hypothetical east slope storage reservoir. Releases from the east slope reservoir matched a typical municipal demand pattern. A ten percent dead storage allowance and a 25 percent contingency allowance was added to the estimated storage requirement. Since the location of such a facility is unknown, its cost was estimated using a direct cost of $1250 per af of total storage provided. This figure is based on a review of the actual cost of recently constructed front range storage facilities and cost estimates of proposed front range storage reservoirs of a comparable size.

- Sensitivity analyses were conducted to test the effect of water rights and instream flow considerations on the potential yield of front range water delivery projects. The Taylor Park Project was used for these analyses because it is the only project under

consideration which lends itself to the preliminary analysis appropriate for the present level of study. This project does not require the modeling of additional west slope reservoirs. Equally important, this project does not require modeling of the physical facilities needed to collect and deliver the water to the new west slope reservoirs. The model results obtained from the Taylor Park Project analysis can be used to infer conclusions related to the other projects.

15.3.2 Identification of Components

Identification of potential components was performed by reviewing existing reports dealing with previously identified projects and by performing a map study to identify new projects not previously studied.

The review of existing literature revealed that three different projects have been proposed previously for the purpose of exporting water out of the Gunnison River Basin. These projects are as follows:

Union Park Project. The water supply component of this project, originally proposed by the Natural Energy Resources Company (EBASCO, 1986), and now being pursued by Arapahoe County, proposes to divert water from the Upper Taylor River Basin to the South Platte Basin.

Collegiate Range Project. This project is being pursued by the City of Aurora (Fleming, 1985 and Aurora 1986) and would divert water from the Upper Taylor River Basin to the South Platte River Basin.

Central Colorado Project. Originally conceived by the USBR (USBR, 1946) and later studied by the Central Colorado Water Conservancy District (Greer, 1972), this project would divert water from the Gunnison River Basin to both the Arkansas and South Platte River Basins.

A fourth alternative which was not studied previously, diverting water directly from Taylor Park Reservoir without the construction of new west slope reservoirs, was identified. Another possibility identified for inclusion in this study consists of pumping uncommitted water from Blue Mesa Reservoir to the South Platte River Basin or the Arkansas River Basin.

The four basic projects considered for out-of-basin water sales are depicted schematically in Figure 15.4. It should be noted that any of the alternatives mentioned above could deliver water to either the South Platte or the Arkansas River Basins.

During the course of the study, a member of the Advisory Committee (Mr. Ralph E. Clark, III) proposed that the Study Team investigate a project that would divert water from the Colorado River near the Utah border and pump it up to the continental divide for use either in the East or West slopes. Mr. Clark coined the name Colorado Aqueduct Return Project (CARP) for this concept. Investigation of this project is outside the geographic and contractual scope of the present study and therefore CARP was not included in the study effort.

15.3.3 Description of Projects

15.3.3.1 Modified Central Colorado Project

The original Central Colorado Project was a transmountain diversion project previously studied by the Central Colorado Water Conservancy District (Greer, 1972). This project is a variation of the Gunnison-Arkansas Project (GUNARK) originally proposed by the USBR (USBR, 1946). The concept evaluated by the District would annually divert 600,000 af of Gunnison Basin water to the South Platte and Arkansas Basins for M&I and supplemental irrigation uses. This concept involved an elaborate collection system utilizing the existing Blue Mesa Reservoir and the proposed Almont, Quartz Creek, and Tomichi Reservoirs connected via gravity tunnels and pump lift pipelines. To attain

the proposed yield, the concept also depended upon increased runoff from weather modification in the form of cloud seeding.

This study evaluated an arrangement which was scaled down from the original concept to consider exporting only water that is presently stored in Blue Mesa Reservoir and is available for purchase under a long term agreement. The project was evaluated on the basis of two potential firm annual yields, 60,000 af and 150,000 af.

The concept analyzed in this study effort consists of a pump lift and pipeline from Blue Mesa Reservoir to the Tomichi Creek Tunnel heading (elevation 8342) which would cross under the continental divide, in a north easterly direction, to the Arkansas River Basin. At this point the water would be discharged directly into the South Arkansas River, a tributary of the Arkansas River. Stream stabilization on the South Arkansas River, down to its confluence with the Arkansas River would be required to accommodate the increased flow regime.

Aqueduct capacity was based on a uniform delivery rate that would transport the annual yield in a one year period with a 13 percent allowance for down time to accommodate maintenance operations (318 day annual operating period). This criteria resulted in a 95 cfs required aqueduct capacity for the 60,000 af annual yield and a 235 cfs capacity for the 150,000 annual yield. These capacities were computed based on pumping from Blue Mesa Reservoir at its minimum power pool elevation of 7390 ft.

The total aqueduct length associated with the Arkansas Basin delivery point, on the South Arkansas River near Maysville, is approximately 52 miles. South Platte delivery was found to be uneconomical due to the 100 mile aqueduct length required and was not considered further. Figure 15.4 presents a schematic diagram which includes this project. A summary of major project features and associated capacities is presented in Table 15.4 for 60,000 af yield and in Table 15.6 for 150,000 af yield. The construction cost estimate

developed for these two yields are presented in Tables 15.5 and 15.7, respectively.

TABLE 15.4

Modified Central Colorado Project Description

CHARACTERISTICS	
Project Firm Annual Yield	60,000 af
Project Power and Energy Requirements	
Power	11.6 MW
Energy	91,381 MWH
Project Power and Energy Produced	
Power	0 MW
Energy	0 MWH

FEATURES	CAPACITY / SIZE
Collection System:	
Existing Blue Mesa Reservoir	
Aqueduct:	
Blue Mesa Pumping Plant Intake Structure	Q=100 cfs
Blue Mesa Pumping Plants	6 ea. @ Q=100 cfs, TDH=194'
Blue Mesa Pipeline	Q=100 cfs, d=5.5', L=180,900'
Tomichi Creek Tunnel	Q=100 cfs, d=10', L= 91,900'
S. Arkansas River Stream Stabilization	Delta Q=100 cfs, L= 66,000'
Transmission Line	69 KV, L=156,000'

TABLE 15.5

Modified Central Colorado Project (60,000 af)
Preliminary Cost Estimate

PROJECT FEATURES	COST
Mobilization	3,737,000
Blue Mesa Pumping Plant Intake Structure	1,464,000
Blue Mesa Pumping Plants	12,768,000
Blue Mesa Pipeline	38,221,000
Tomichi Creek Tunnel	128,660,000
South Arkansas River Stream Stabilization	2,112,000
Transmission Line	3,642,000
Miscellaneous Items (10%)	19,060,000
Subtotal Direct Cost	209,664,000
Contingencies (25%)	52,416,000
Total Direct Cost	262,080,000
Engineering, Legal, and Administration (15%)	39,312,000
Total Construction Cost	301,392,000
Interest During Construction (8% over 5 years)	66,110,000
Total Capital Cost	367,502,000
Debt Service Reserve Fund (1 year debt service)	36,417,000
Financing Expenses	6,059,000
Total Investment Cost	409,978,000
Annual Debt Service (8% over 30 years)	36,417,000
Annual O&M Cost	1,992,000
Annual Energy and Power Cost	3,773,000
Annual Energy and Power Revenues	0
Blue Mesa Water Purchase	3,000,000
Total Annual Cost	45,182,000

TABLE 15.6

Modified Central Colorado Project

CHARACTERISTICS	
Project Firm Annual Yield	150,000 af
Project Power and Energy Requirements	
Power	29.9 MW
Energy	235,408 MWH
Project Power and Energy Produced	
Power	0 MW
Energy	0 MWH

FEATURES	CAPACITY / SIZE
Collection System:	
Existing Blue Mesa Reservoir	
Aqueduct:	
Blue Mesa Pumping Plant Intake Structure	Q=235 cfs
Blue Mesa Pumping Plants	4 ea. @ Q=235 cfs, TDH=319′
Blue Mesa Pipeline	Q=235 cfs, d=7′, L=180,900′
Tomichi Creek Tunnel	Q=235 cfs, d=10′, L= 92,000′
S. Arkansas River Stream Stabilization	Delta Q=235 cfs, L= 66,000′
Transmission Line	69 KV, L=139,000′

TABLE 15.7

Modified Central Colorado Project (150,000 af)
Preliminary Cost Estimate

PROJECT FEATURES	COST
Mobilization	4,522,000
Blue Mesa Pumping Plant Intake Structure	3,441,000
Blue Mesa Pumping Plants	22,960,000
Blue Mesa Pipeline	65,521,000
Tomichi Creek Tunnel	128,800,000
South Arkansas River Stream Stabilization	2,112,000
Transmission Line	3,245,000
Miscellaneous Items (10%)	23,060,000
Subtotal Construction Cost	253,661,000
Contingencies (25%)	63,415,000
Direct Construction Cost	317,076,000
Engineering, Legal, and Administration (15%)	47,561,000
Total Construction Cost	364,637,000
Interest During Construction (8% over 5 years)	79,983,000
Total Capital Cost	444,620,000
Debt Service Reserve Fund	44,059,000
Financing Expenses	7,330,000
Total Investment Cost	496,009,000
Annual Debt Service (8% over 30 years)	44,059,000
Annual O&M Cost	2,410,000
Annual Energy and Power Cost	9,721,000
Annual Energy and Power Revenues	0
Blue Mesa Water Purchase	7,500,000
Total Annual Cost	63,690,000

15.3.3.2 Collegiate Range Project

The Collegiate Range Project is a transmountain diversion project proposed by the City of Aurora. The project description that follows was obtained from published data (Aurora, 1986) and drawings provided to the Authority by the City of Aurora.

The project would collect Gunnison Basin water for diversion to Antero Reservoir by constructing Pieplant Reservoir on the Taylor River immediately upstream from Taylor Park Reservoir. Flow from Texas Creek would also be diverted directly into Pieplant Reservoir via a small diversion dam and gravity flow Texas Creek Pipeline. Below this diversion dam the entire flow of Texas Creek would be diverted into the Texas Creek Diversion Channel and discharged into the Taylor River below Pieplant Reservoir to maintain the CWCB minimum streamflow decree of 55 cfs. Flows in excess of the 55 cfs minimum would be pumped into Pieplant Reservoir by the Relift Pumping Plant. Additional water would be collected from Taylor Park Reservoir via the Lakeshore Pumping Plant and pipeline which would discharge into the Texas Creek Diversion Channel for storage in Pieplant Reservoir via the Relift Pumping Plant. The Collegiate Range water collection system is shown in Figure 15.5.

Almont Reservoir would be constructed on the East River to satisfy senior downstream water rights impacted by the east slope diversions. Estimated average annual yield from this collection system is 73,100 af (Fleming, 1985) based on a 1969-1983 operation study. It should be noted however, that the firm annual yield to the east slope from this project was not reported. The operation study showed that there was no divertable water available for a 23-month period (August of Water Year 1976 through June of Water Year 1978) of the 15-year period studied. An operation study which includes Aurora's entire system including their east slope storage facilities would be required to define the project's firm yield.

Gunnison Basin water would be transported to Antero Reservoir from Pieplant Reservoir via a 42 mile gravity aqueduct consisting of pipelines, siphons, and tunnels. Sizing of the water conductor was performed by the study team based on the 150 cfs aqueduct capacity stated in Fleming's report with Pieplant Reservoir at its minimum pool elevation of 9,440 ft and Antero Reservoir at its maximum pool elevation of 8,940 ft. This aqueduct capacity could transport the project's reported average annual yield in a 246 day period assuming a uniform flow rate throughout the period.

The aqueduct would start at an intake structure in Pieplant Reservoir that would control the flow of water into the Ice Mountain Tunnel. This tunnel would cross under the continental divide in an east northeasterly direction and emerge in the Pine Creek drainage, a tributary of the Arkansas River. A pipeline and siphon would conduct the water across the Arkansas River Valley. From there a series of pipelines and tunnel segments following the 9,600 ft contour in a southeasterly direction would convey the water to the Trout Creek Tunnel heading. This tunnel would cross under Trout Creek Pass in a northeasterly direction and emerge in the Salt Creek drainage, a tributary of the South Platte River. At this point the water would be discharged directly into Salt Creek and would then flow into Antero Reservoir. An allowance was made in the cost estimate for Salt Creek stream stabilization to accommodate the increased flow regime.

Available data and reports related to this project did not include east slope storage requirements. The City indicated that front range storage is not a required element of the Collegiate Range Project (personal communication with Mr. Doug Kemper, Manager of Water Resources).

Figure 15.4 presents a schematic diagram which includes this project. A detailed summary of major features and associated capacities is presented in Table 15.8. As shown on Table 15.9, the total construction cost estimate developed by this study effort is approximately $420 million. The City of Aurora has published an estimate of total construction cost which ranges from

$250 to $320 million. This cost would be equivalent to $265 to $340 million in January 1989 prices.

TABLE 15.8

Collegiate Range Project
Project Description 1/

CHARACTERISTICS

Average Annual Yield	73,100 af
Project Power and Energy Requirements	
Power	4.6 MW
Energy	35,905 MWH
Project Power and Energy Produced	
Power	0 MW
Energy	0 MWH

FEATURES	CAPACITY / SIZE
Collection System:	
Pieplant Reservoir	65,000 af
Almont Reservoir	92,000 af
Texas Creek Gravity Pipeline	Q=250 cfs, d=6', L=9,300'
Texas Creek Pipeline Diversion Dam	Q=250 cfs
Texas Creek Diversion Channel	Q=500 cfs, s=0.0012, L=8,400'
Texas Creek Channel Diversion Dam	Q=500 cfs
Lakeshore Pipeline	Q=150 cfs, d=6', L=2,600'
Lakeshore Pumping Plant	1 EA. @Q=150 cfs, TDH=189'
Lakeshore Pumping Plant Intake Structure	Q=150 cfs
Relift Pipeline	Q=95cfs, d=5', L=1,500'
Relift Pumping Plant	1 EA. @ Q=95 cfs, TDH=183'
Relift Pumping Plant Intake Structure	Q=95 cfs
Aqueduct:	
Ice Mountain Tunnel Intake Structure	Q=150 cfs
Ice Mountain Tunnel	Q=150 cfs, d=10', L=90,300'
Pine Creek Pipeline	Q=150 cfs, d=7', L=11,800'
Arkansas Valley Siphon	Q=150 cfs, d=7', L= 1,900'
Langhoff Gulch Pipeline	Q=150 cfs, d=7', L= 3,500'
Langhoff Gulch Tunnel	Q=150 cfs, d=10', L= 400'
San Isabel Pipeline	Q=150 cfs, d=7', L=34,100'
San Isabel Tunnel	Q=150 cfs, d=10', L= 4,100'
Fourmile Creek Pipeline	Q=150 cfs, d=7', L=36,700'
Trout Creek Pass Tunnel	Q=150 cfs, d=10', L=20,100'
Salt Creek Pipeline	Q=150 cfs, d=7', L= 6,300'
Salt Creek Stream Stabalization	Delta Q=150 cfs, L=21,000'
Transmission Line	69 KV, L=150,000'

1/ Data obtained from Collegiate Range Project Summary Report, May 1986.

TABLE 15.9

Collegiate Range Project
Preliminary Cost Estimate

PROJECT FEATURES	COST
Mobilization	5,205,000
Almont Dam	28,585,000
Pieplant Dam	20,675,000
Texas Creek Gravity Pipeline	1,965,000
Texas Creek Pipeline Diversion Dam	250,000
Texas Creek Diversion Channel	1,714,000
Texas Creek Channel Diversion Dam	250,000
Lakeshore Pipeline	654,000
Lakeshore Pumping Plant	2,975,000
Lakeshore Pumping Plant Intake Structure	2,214,000
Relift Pipeline	272,000
Relift Pumping Plant	1,965,000
Relift Pumping Plant Intake Structure	100,000
Ice Mountain Tunnel Intake Structure	1,000,000
Ice Mountain Tunnel	126,420,000
Pine Creek Pipeline	4,630,000
Arkansas Valley Siphon	2,618,000
Langhoff Gulch Pipeline	1,373,000
Langhoff Gulch Tunnel	480,000
San Isabel Pipeline	12,351,000
San Isabel Tunnel	4,920,000
Fourmile Creek Pipeline	14,400,000
Trout Creek Pass Tunnel	24,120,000
Salt Creek Pipeline	2,155,000
Salt Creek Stream Stabilization	672,000
Transmission Line	3,502,000
Miscellaneous Items (10%)	26,547,000
Subtotal Direct Cost	292,012,000
Contingencies (25%)	73,003,000
Total Direct Cost	365,015,000
Engineering, Legal, and Administration (15%)	54,752,000
Total Construction Cost	419,767,000
Interest During Construction (8% over 5 years)	92,076,000
Total Capital Cost	511,843,000
Debt Service Reserve Fund (1 year debt service)	50,721,000
Financing Expenses	8,438,000
Total Investment Cost	571,002,000
Annual Debt Service (8% over 30 years)	50,721,000
Annual O&M Cost	2,774,000
Annual Energy and Power Cost	1,483,000
Annual Energy and Power Revenues	0
Blue Mesa Water Purchase	0
Total Annual Cost	54,978,000

15.3.3.3 Union Park Water Supply Project

The Union Park Project is a transmountain diversion project proposed by the Natural Energy Resource Company (NECO). Arapahoe County acquired NECO's interest in the project on August 29, 1988 and now owns the project. The project consists of Union Park Dam on Lottis Creek, a tributary of the Taylor River which joins the Taylor River approximately 4 miles downstream from Taylor Park Reservoir, and an aqueduct extending from Union Park Reservoir to Antero Reservoir. Union Park Reservoir is planned for a total storage capacity of 900,000 af with an active capacity of 785,000 af. Figure 15.6 shows the Union Park water collection system.

The majority of Gunnison Basin water collected for transport to Antero Reservoir would be pumped from Taylor Park Reservoir to Union Park Reservoir, an average pump lift of approximately 700 ft. A large capacity reversible pump/turbine unit would pump up to 60,000 af per month of spring runoff inflows from Taylor Park Reservoir into the proposed Union Park Reservoir. This facility will operate as a pump-storage hydroelectric generating plant during low inflow periods to Taylor Park when water would not be available for storage in Union Park. The remainder of the project yield would come from Lottis Creek inflow to Union Park Reservoir.

Gunnison Basin water would be transported from Union Park Reservoir to Antero Reservoir via a 40 mile gravity aqueduct consisting of pipelines, siphons, and tunnels. The aqueduct sizing presented in "Union Park Water Supply Project Reconnaissance Evaluation Study" (NECO, 1986) was used in this study.

The aqueduct would start at an intake structure in Union Park Reservoir which would control the flow of water into the Union Park Tunnel. This tunnel would cross under the continental divide in an easterly direction and emerge in the South Cottonwood Creek drainage, a tributary of the Arkansas River. A pipeline following South Cottonwood Creek in an easterly direction would conduct water to a siphon crossing the Arkansas River Valley one mile north of

Buena Vista. From this point a series of pipelines, tunnels, and siphons would convey water in a northeasterly direction to the Trout Creek Pass Tunnel heading. This tunnel would cross under Trout Creek Pass in a northeasterly direction and emerge in the Salt Creek drainage, a tributary of the South Platte River. At this point the water would be discharged directly into Salt Creek. An allowance was made in the cost estimate for Salt Creek stream stabilization to accommodate the increased flow regime.

The average annual diversion into the Union Park reservoir was estimated by NECO (EBASCO, 1986) to be 60,000 af. The project is intended and configured to store wet year yield and to deliver water in large volumes during dry years. The EBASCO report discusses a range of potential yields depending on who the end-user is, how the project is operated, and on what other projects are included in the end-users system. The project yields cited in the EBASCO report range from 60,000 af to 180,000 af annually. The U.S. Corps of Engineers (USCOE) performed a detailed operation study of the Union Park Project assuming it would be operated as an integral part of the Denver Water Department's raw water supply system (USCOE, 1988). This operation study indicated that the safe annual yield of the Union Park Project would range from 63,000 to 111,000 af under the operational assumptions used. The report noted that this yield could only be achieved if there were no releases from the Union Park Reservoir to any other users except for instream flow maintenance in Lottis Creek and Taylor River.

A summary of major features and associated capacities is presented in Table 15.10. The cost estimate developed by this study is presented on Table 15.11. The $591 million total construction cost presented on Table 15.11 compares to a total construction cost of $420 million developed by NECO and indexed to January 1989 price levels.

TABLE 15.10

Union Park Water Supply Project

CHARACTERISTICS

Project Firm Annual Yield (Inflow to Union Park Reservoir)	60,000 af *
Project Power and Energy Requirements	
Power	60.0 MW *
Energy	161,160 MWH
Project Power and Energy Produced	
Power	60.0 MW *
Energy	84,600 MWH

FEATURES	CAPACITY / SIZE
Collection System:	
Union Park Reservoir	900,000 af *
Union Park Inlet/Outlet Structure	Q=1,000 - 1,450 cfs *
Union Park Intake Channel	Q=1,000 - 1,450 cfs *
Taylor Park Inlet/Outlet Structure	Q=1,000 - 1,450 cfs *
Taylor Park to Union Park Penstock	Q=1,000-1,450 cfs, * * d=8.5-11', L=11,400'
Power/Pumping Plant Structures	1 EA.
Pump/Turbine and Motor/Generator	* 1 EA. 60 MW, Q=1,000-1,450 cfs *
Accessory Electrical and Misc. Equip.	L.S.
Access Tunnels and Cableway	* d=11', L=5,700'
Aqueduct:	
Union Park Tunnel	* Q=450 cfs, * d=11', L=75,400'
South Cottonwood Creek Pipeline	* Q=450 cfs, * d=6', L=15,500'
Arkansas Valley Siphon	* Q=450 cfs, * d=6', L=64,300'
Sevenmile Creek Pipeline	* Q=450 cfs, * d=6', L= 4,300'
Trout Creek Pass Tunnel	* Q=450 cfs, * d=11', L=29,900'
Salt Creek Creek Stream Stabilization	Delta Q=450 cfs, L=23,000'
Transmission Line	69 KV, L=150,000'

* Data obtained from Union Park Water Supply Project Reconnaissance Evaluation Study, October 1986. Items not marked with an asterisk (*) were developed by the Study Team.

TABLE 15.11

Union Park Project
Preliminary Cost Estimate

PROJECT FEATURES	COST
Mobilization	7,332,000
Union Park Dam	49,162,000
Union Park Inlet/Outlet Structure	4,000,000
Union Park Intake Channel	1,059,000
Taylor Park Inlet/Outlet Structure	3,000,000
Taylor Park to Union Park Water Conveyance System	15,960,000
Power/Pumping Plant Structure and Improvements	5,094,000
Pump/Turbine and Motor/Generator	10,086,000
Accessory Electrical and Miscellaneous Equipment	1,998,000
Access Tunnels and Cableway	6,840,000
Union Park Tunnel	105,560,000
South Cottonwood Creek Pipeline	5,050,000
Arkansas Valley Siphon	117,344,000
Sevenmile Creek Pipeline	1,313,000
Trout Creek Pass Tunnel	35,880,000
Salt Creek Stream Stabilization	736,000
Transmission Line	3,509,000
Miscellaneous Items (10%)	37,392,000
Subtotal Direct Cost	411,315,000
Contingencies (25%)	102,829,000
Total Direct Cost	514,144,000
Engineering, Legal, and Administration (15%)	77,122,000
Total Construction Cost	591,266,000
Interest During Construction (8% over 5 years)	129,694,000
Total Capital Cost	720,960,000
Debt Service Reserve Fund (1 year debt service)	71,443,000
Financing Expenses	11,886,000
Total Investment Cost	804,289,000
Annual Debt Service (8% over 30 years)	71,443,000
Annual O&M Cost	3,907,000
Annual Energy and Power Cost	11,668,000
Annual Energy and Power Revenues	8,644,000
Blue Mesa Water Purchase	0
Total Annual Cost	78,374,000

15.3.3.4 Taylor Park Project

The Taylor Park Project, as developed by this study effort, would maximize the use of existing storage facilities in the Gunnison Basin. Taylor Park Reservoir would serve as the collection facility for Gunnison Basin water to be diverted to Antero Reservoir. Replacement water for downstream water users would be provided from Blue Mesa Reservoir under long term contract with the U.S. Department of the Interior. A number of alternative project configurations consisting of total gravity diversion, combination pump lift and gravity, and different water conductor routes, were evaluated for this project. The following describes the combined pump lift and gravity project configuration selected as the most economically attractive Taylor Park project variation.

Gunnison Basin water would be transported to the South Platte River basin near Antero Reservoir directly from Taylor Park Reservoir. A pump station located at the Taylor Park Reservoir would lift water 650 feet to the Divide Tunnel heading. The water would then be conveyed to Antero Reservoir by an aqueduct consisting of pipelines, siphons, and tunnels. The total water conductor length is about 36 miles. Aqueduct sizing was based on a uniform delivery rate that would transport an average annual yield of 42,000 af per year with about a 10 percent allowance for down time to accommodate maintenance operations. This criteria resulted in a 65 cfs aqueduct capacity assuming Taylor Park at its minimum pool elevation of 9,200 ft and Antero at its maximum pool elevation of 8940 ft.

The aqueduct would start at the Taylor Park pump station and then proceed to the Taylor Park Tunnel. This tunnel would cross under the continental divide in an easterly direction and emerge in the Middle Cottonwood Creek drainage, a tributary of the Arkansas River. A pipeline following Cottonwood Creek in an easterly direction would conduct water to a siphon crossing the Arkansas River Valley one mile north of Buena Vista. From this point a series of pipelines, tunnels, and siphons would convey water in a northeasterly direction to the Trout Creek Pass Tunnel heading. This tunnel would cross

under Trout Creek Pass in a northeasterly direction and emerge in the Salt Creek drainage, a tributary of the South Platte River. At this point the water would be discharged directly into Salt Creek. An allowance was made in the cost estimate for Salt Creek stream stabilization to accommodate the increased flow regime.

Since this potential project diverts water to the east slope at a constant uniform rate, storage on the east slope may be required to effectively utilize the imported water. The need for and amount of east slope storage required will differ depending on the system characteristics of the end user. Quantification of the east slope storage needs would require integrated system operation studies for each potential end user's system. A more general approach was used instead.

Front range storage requirements were estimated based on a uniform inflow rate to the facility with withdrawals matched to a typical municipal demand pattern. The required active storage was then computed using the Sequent Peak Procedure (Loucks, 1981). The result was increased by 10 percent to allow for dead storage and then a 25 percent contingency was added. This resulted in a total front range storage capacity of 12,000 af required to reregulate the 42,000 af Taylor Park Project diversion. The storage cost was estimated using a direct cost of $1250 per af of total storage required. This figure is based on a review of the actual cost of recently constructed front range storage projects and cost estimates contained in planning studies of proposed front range reservoirs of similar size.

Figure 15.7 shows a plan and profile of the project. A detailed summary of major features and associated capacities is presented on Table 15.12. The project cost estimate is presented on Table 15.13. The unit cost of Taylor Park water (based on capital cost) is $7150 per af of average annual yield.

TABLE 15.12

Taylor Park Project

DESCRIPTION

Pump Lift From Taylor Park, Buena Vista Route, Antero Reservoir Delivery

CHARACTERISTICS

Project Average Annual Yield	42,000 af
Project Minimum Annual Yield	36,500 af
Project Power and Energy Requirements	
Power	4.5 MW
Energy	35,516 MWH
Project Power and Energy Produced	
Power	0 MW
Energy	0 MWH

FEATURES	CAPACITY / SIZE
Collection System:	
Existing Taylor Park Reservoir	106,000 af
Aqueduct:	
Taylor Park Pumping Plant	Q=65 cfs
Intake Structure	
Taylor Park Pumping Plant	2 EA. @ Q=65 cfs, TDH=348'
Taylor Park Pipeline	Q=65 cfs, d=4', L=35,000'
Divide Tunnel	Q=65 cfs, d=10', L=45,300'
Cottonwood Creek Pipeline	Q=65 cfs, d=4', L=15,500'
Arkansas Valley Siphon	Q=65 cfs, d=4', L=66,200'
Hop Gulch Pipeline	Q=65 cfs, d=4', L= 4,700'
Trout Creek Pass Tunnel	Q=65 cfs, d=10', L=10,500'
County Line Pipeline	Q=65 cfs, d=4', L=12,400'
Salt Creek Stream Stabilization	Delta Q=65 cfs, L=28,000'
Transmission Line	69 KV, L=138,000'

TABLE 15.13

Taylor Park Project (42,000 af)
Preliminary Cost Estimate

PROJECT FEATURES	COST
Mobilization	2,760,000
Taylor Park Pumping Plant Intake Structure	959,000
Taylor Park Pumping Plants	4,172,000
Taylor Park Pipeline	5,282,000
Divide Tunnel	54,360,000
Cottonwood Creek Pipeline	2,573,000
Arkansas Valley Siphon	51,260,000
Hop Gulch Pipeline	780,000
Trout Creek Pass Tunnel	12,600,000
County Line Pipeline	1,871,000
Salt Creek Stream Stabilization	896,000
Transmission Line	3,222,000
South Platte Regulating Reservoir	15,000,000
Miscellaneous Items (10%)	15,574,000
Subtotal Direct Cost	171,309,000
Contingencies (25%)	42,827,000
Total Direct Cost	214,136,000
Engineering, Legal, and Administration (15%)	32,120,000
Total Construction Cost	246,256,000
Interest During Construction (8% over 5 years)	54,016,000
Total Capital Cost	300,272,000
Debt Service Reserve Fund (1 year debt service)	29,755,000
Financing Expenses	4,950,000
Total Investment Cost	334,977,000
Annual Debt Service (8% over 30 years)	29,755,000
Annual O&M Cost	1,627,000
Annual Energy and Power Cost	1,467,000
Annual Energy and Power Revenues	0
Blue Mesa Water Purchase	325,000
Total Annual Cost	33,174,000

The Taylor Park Project discussed above is configured to divert water only from the Upper Taylor River Basin. A pump lift component that would convey water from Blue Mesa Reservoir to Taylor Park Reservoir could be added to the project in order to increase the total project yield without increasing impacts to the upper basin streamflows. This variation of the Taylor Park Project was investigated using 58,000 af per year pump lift from Blue Mesa Reservoir resulting in a total project average annual yield of 100,000 af. Table 15.12A summarizes the project features and Table 15.13A presents a preliminary cost estimate for this variation. The unit capital cost of water from this variation is $5310 per af of average annual yield.

TABLE 15.12A

Taylor Park Project with Blue Mesa Imports

DESCRIPTION

Pump Lift From Blue Mesa to Taylor Park, Pump Lift From Taylor Park, Buena Vista Route, Antero Reservoir Delivery

CHARACTERISTICS

Project Average Annual Yield	100,000 af
Project Minimum Annual Yield	94,500 af
Project Power and Energy Requirements	
Power	32.6 MW
Energy	257,335 MWH
Project Power and Energy Produced	
Power	0 MW
Energy	0 MWH

FEATURES	CAPACITY / SIZE
Collection System:	
Existing Taylor Park Reservoir	106,000 af
Existing Blue Mesa Reservoir	941,000 af
Aqueduct:	
Blue Mesa Pumping Plant Intake Structure	Q=90 cfs
Blue Mesa Pumping Plants	9 EA. @ Q=90 cfs, TDH=278′
Blue Mesa Pipeline	Q=90 cfs, d=4.5′, L=187,400′
Taylor Park Pumping Plant Intake Structure	Q=155 cfs
Taylor Park Pumping Plant	2 EA. @ Q=155 cfs, TDH=331′
Taylor Park Pipeline	Q=155 cfs, d=6′, L=35,000′
Divide Tunnel	Q=155 cfs, d=10′, L=45,400′
Cottonwood Creek Pipeline	Q=155 cfs, d=5′, L=15,100′
Arkansas Valley Siphon	Q=155 cfs, d=5′, L=64,500′
Hop Gulch Pipeline	Q=155 cfs, d=5′, L= 5,300′
Trout Creek Pass Tunnel	Q=155 cfs, d=10′, L=14,100′
County Line Pipeline	Q=155 cfs, d=5′, L= 5,900′
County Line Tunnel	Q=155 cfs, d=10′, L= 6,400′
Salt Creek Stream Stabilization	Delta Q=155 cfs, L=27,000′
Transmission Line	69 KV, L=207,000′

TABLE 15.13A

Taylor Park Project with Blue Mesa Imports (100,000 af)
Preliminary Cost Estimate

PROJECT FEATURES	COST
Mobilization	4,693,000
Blue Mesa Pumping Plant Intake Structure	1,318,000
Blue Mesa Pumping Plants	21,438,000
Blue Mesa Pipeline	31,110,000
Taylor Park Pumping Plant Intake Structure	2,287,000
Taylor Park Pumping Plants	8,434,000
Taylor Park Pipeline	9,860,000
Divide Tunnel	54,480,000
Cottonwood Creek Pipeline	3,494,000
Arkansas Valley Siphon	69,614,000
Hop Gulch Pipeline	1,226,000
Trout Creek Pass Tunnel	16,920,000
County Line Pipeline	1,068,000
County Line Tunnel	7,680,000
Salt Creek Stream Stabilization	864,000
Transmission Line	4,833,000
South Platte Regulating Reservoir	36,000,000
Miscellaneous Items (10%)	27,532,000
Subtotal Direct Cost	302,851,000
Contingencies (25%)	75,713,000
Total Direct Cost	378,564,000
Engineering, Legal, and Administration (15%)	56,785,000
Total Construction Cost	435,349,000
Interest During Construction (8% over 5 years)	95,494,000
Total Capital Cost	530,843,000
Debt Service Reserve Fund (1 year debt service)	52,603,000
Financing Expenses	8,752,000
Total Investment Cost	592,198,000
Annual Debt Service (8% over 30 years)	52,603,000
Annual O&M Cost	2,877,000
Annual Energy and Power Cost	10,626,000
Annual Energy and Power Revenues	0
Blue Mesa Water Purchase	3,225,000
Total Annual Cost	69,331,000

15.3.4 Hydrologic Evaluation of Basin Export Projects

As discussed previously, the hydrologic yield of the Collegiate Range Project and the Union Park Project have been accepted from previously published reports. The Modified Central Colorado Project derives its yield from the purchase of uncommitted Blue Mesa Reservoir water and therefore can be any value up to the estimated 180,000 af available. The Taylor Park Project has not been studied in the past and therefore a yield analysis was performed for that project.

15.3.4.1 Use of Existing Water Rights

Three existing basin water rights were considered to support basin export projects. These three are: 1) export under the UVWUA storage decree in Taylor Park Reservoir, 2) export from Taylor Park under transferred UGRWCD conditional decrees, and 3) pumping directly from Blue Mesa, where up to 180,000 af is available for contract sale as discussed earlier. Water from the Dallas Creek Project supply might also be purchased and the water right might be transferred to an appropriate point such as Taylor Park Reservoir for transbasin diversion. It should be noted that other conditional storage decrees exist in the basin which might also be transferred to support this project. These alternatives would require Water Court proceedings or changes in existing agreements. The institutional issues involved in these actions are potentially very complex, but the possibility that a cooperative effort might lead to greater benefits for both in-basin users and exporters suggests that they may find resolution. One example from these three is described herein in detail, namely the use of UVWUA storage in Taylor Park. The following discussion does <u>not</u> imply that the Board of Directors of the UVWUA or the USBR anticipates or supports such a use of the water rights.

15.3.4.2 Export From Existing Taylor Park Reservoir Under UVWUA Storage Decree

This example was included to illustrate the benefits and impacts of using existing basin rights to support potential export water sales. Under this arrangement, any shortage to the UVWUA Taylor Park Exchange account would be made up by the water exporter through the purchase of replacement water from Blue Mesa Reservoir.

Exports would be made directly from the existing Taylor Park Reservoir. No new reservoirs or enlargement of existing reservoirs on the west slope are included in this arrangement. Withdrawals would be made from water stored under the UVWUA's 111,260 af storage decree. Exports were assumed to be made at a constant rate with re-regulation storage being provided at an unspecified location outside of the basin. All three proposed in-basin reservoirs were assumed to be in place in order to assess the impact of an export project on their operation.

Taylor Park Reservoir operations were modified by the removal of the forecast rule because this rule results in reservoir evacuation without consideration of exports which perform the same function. Two additional operating rules were imposed. One rule is to make operational releases for maintenance of instream flow regimes below Taylor Park Dam. The other is to maintain a minimum target level of storage in Taylor Park Reservoir. These two operating rules were assumed to take precedence over export; that is at times when water availability is insufficient to meet the two rules and export requirements, the export was curtailed.

Three different instream flow regimes were used to investigate the impact of alternative downstream flow requirements on export yields. Regime I corresponds to the CWCB's decreed instream flow rates. Regime II provides a somewhat greater flow and closely simulates the present target releases provided for in the Taylor Park Exchange Agreement. Regime III provides even higher flow levels. Table 15.14 summarizes these three regimes.

TABLE 15.14

Instream Flow Regimes

Flow Regime	Instream Flow Targets Below Taylor Park Dam	
I	Oct-Apr	50 cfs
	May-Sep	100 cfs
II	Oct-Mar	75 cfs
	Apr	100 cfs
	May-Jul	150 cfs
	Aug, Sep	100 cfs
III	Oct-Mar	75 cfs
	Apr	100 cfs
	May-Jun 15	150 cfs
	Jun 15-Aug 15	300 cfs
	Aug 15-Sep	100 cfs

The minimum target storage level used for Taylor Park Reservoir was 23,400 af (water surface elevation 9268 ft). This value corresponds to the April 1981 storage content which is the lowest level in recent years. The lowest level recorded in the period of record was 8780 af (elevation 9240.7) in 1956. Taylor Park Reservoir does not have a conservation pool requirement and therefore the UVWUA has the legal right to empty the reservoir if necessary. The U.S. Fish and Wildlife Service guidelines for reservoir drawdown suggest a minimum target level of approximately 16,000 af for fishery maintenance at Taylor Park Reservoir.

The instream flow release was assumed to have the highest priority, minimum reservoir level to have the next highest, and the basin export to have the lowest. For example, instream flow releases are allowed to draw storage below the minimum level, but exports would be curtailed if such a drawdown would result.

The model was operated in an iterative fashion to determine the highest export rate that could be achieved without infringing on the instream flow or minimum reservoir storage criteria. The export rates were allowed to drop

below the target rate on a limited basis. Therefore the average annual yield and the minimum annual yield do not correspond to the monthly target export rate times 12 months per year. Rather, the average annual yield is the average of the annual yields during the 32 year period modeled (1952-1983) while the minimum annual yield is the lowest annual yield achieved during that period. The three instream flow regimes define three modeling scenarios; that is, regimes I, II, and III were represented in Scenarios 7, 8, and 9, respectively. Table 15.15 summarizes the results of the three scenarios. The middle scenario, Scenario 8, is discussed in greater detail below.

TABLE 15.15

Summary of Results

Scenario	Flow Regime	Target Export Rate (af/mo)	Average Annual Yield (af/yr)	Minimum Annual Yield (af/yr)	Min. Taylor Park Res. Storage (af)
7	I	5,000	59,880	56,088	23,309
8	II	3,500	41,828	36,521	23,309
9	III	2,000	23,840	18,900	22,386

In the export scenarios listed in Table 15.15, the minimum yield typically occurs immediately following the dry years of 1956 or 1977 and is the result of low reservoir storage in the early spring prior to runoff. This low reservoir storage causes exports to be curtailed according to the operating policies described above. Table 15.16 shows the export pattern represented in Scenario 8.

In Scenario 8, instream flow targets below Taylor Park dam are always met and are frequently exceeded in June and July. This indicates that a modification of the project configuration to allow greater diversions at

certain times would increase the average annual yield of the project. Table 15.17 lists the monthly instream flows below the dam for this scenario.

Taylor Park Reservoir operates at a higher level than in the No-Action Alternative (Scenario 1), primarily due to the deletion of forecast operations, while Blue Mesa operates at a Lower level. Modification of the Blue Mesa Reservoir operating rules with an export project in place could probably reduce the difference in reservoir levels between Scenarios 8 and 1. Figures 15.8 and 15.9 show the reservoir levels for these two reservoirs under Scenario 8. Figure 15.10 illustrates the difference in reservoir level between Scenario 8 and Scenario 1 for Blue Mesa Reservoir. Contents of the three new in-basin reservoirs are indistinguishable from those of Scenario 2B.

The Black Canyon minimum instream flow target of 300 cfs is consistently met by releases from Blue Mesa. The average Blue Mesa release for this purpose is 24,800 af/yr, as compared with 22,000 af/yr in Scenario 1. Black Canyon flows and operational releases from Blue Mesa Reservoir are shown in Tables 15.18 and 15.19.

Gunnison Tunnel diversions under Scenario 8, shown in Table 15.20, are slightly less than those of either Scenario 1 or Scenario 2B. However, no shortages are induced to UVWUA agricultural demands.

The average monthly exchange credit in Blue Mesa is reduced from the Scenario 2B level of 5228 af/mo to a level of 1697 af/mo in Scenario 8. This results in the Taylor Park Exchange operating at a lower overall level, as depicted in Figure 15.11. Although this reduces the reliability of the exchange, storage credits are still high enough that the purchase of replacement water from Blue Mesa for UVWUA is required in only 61 of the 384 months of the study period. The maximum purchase in a 12 month period is 58,000 af, and the average annual purchase over the study period is 6500 af/yr.

TABLE 15.16

Scenario 8 Results
Exports from Taylor Reservoir
Values in AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1953	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1954	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1955	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1956	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1957	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1958	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1959	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1960	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1961	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1962	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1963	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1964	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1965	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1966	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1967	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1968	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1969	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1970	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1971	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1972	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1973	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1974	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1975	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1976	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1977	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1978	3500	3500	3500	3500	3500	771	750	3500	3500	3500	3500	3500	36521
1979	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1980	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1981	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1982	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
1983	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
Average	3500	3500	3500	3500	3500	3415	3414	3500	3500	3500	3500	3500	41829
Std.Dev	0	0	0	0	0	475	478	0	0	0	0	0	953
Maximum	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	42000
Minimum	3500	3500	3500	3500	3500	771	750	3500	3500	3500	3500	3500	36521

TABLE 15.17

Scenario 8 Results
Taylor River Below Taylor Reservoir
Average Monthly Flow (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	75	75	75	75	75	75	100	150	520	358	162	100	153
1953	75	75	75	75	75	75	100	150	422	217	100	100	128
1954	75	75	75	75	75	75	100	150	150	150	100	100	100
1955	75	75	75	75	75	75	100	150	150	150	100	100	100
1956	75	75	75	75	75	75	100	150	154	150	100	100	100
1957	75	75	75	75	75	75	100	150	816	1158	364	123	265
1958	75	75	75	75	75	75	100	251	577	150	100	100	144
1959	75	75	75	75	75	75	100	150	150	150	100	100	100
1960	75	75	75	75	75	75	100	150	186	210	100	100	108
1961	75	75	75	75	75	75	100	150	150	150	100	100	100
1962	75	75	75	75	75	75	100	322	897	441	103	100	201
1963	75	75	75	75	75	75	100	150	150	150	100	100	100
1964	75	75	75	75	75	75	100	150	150	150	100	100	100
1965	75	75	75	75	75	75	100	150	245	761	273	124	177
1966	103	75	75	75	75	75	100	244	341	150	100	100	126
1967	75	75	75	75	75	75	100	150	283	235	100	100	118
1968	75	75	75	75	75	75	100	150	343	208	248	100	134
1969	75	75	75	75	75	75	100	164	601	358	116	100	157
1970	75	75	75	75	75	75	100	387	784	327	129	219	200
1971	128	75	75	75	75	75	100	159	727	339	143	100	172
1972	75	75	75	75	75	75	100	150	625	150	100	100	139
1973	75	75	75	75	75	75	100	150	375	360	100	100	136
1974	75	75	75	75	75	75	100	150	260	150	100	100	109
1975	75	75	75	75	75	75	100	150	150	233	100	100	107
1976	75	75	75	75	75	75	100	150	189	186	100	100	106
1977	75	75	75	75	75	75	100	150	150	150	100	100	100
1978	75	75	75	75	75	75	100	150	150	150	100	100	100
1979	75	75	75	75	75	75	100	150	150	419	146	100	127
1980	75	75	75	75	75	75	100	150	862	326	100	100	174
1981	75	75	75	75	75	75	100	150	150	150	100	100	100
1982	75	75	75	75	75	75	100	150	150	150	100	121	102
1983	79	75	75	75	75	75	100	150	531	472	217	100	169
Average	78	75	75	75	75	75	100	170	361	277	128	106	133
Std Dev	10	0	0	0	0	0	0	54	247	209	61	21	39
Maximum	128	75	75	75	75	75	100	387	897	1158	364	219	265
Minimum	75	75	75	75	75	75	100	150	150	150	100	100	100
CWCB DECREE	50	50	50	50	50	50	50	100	100	100	100	100	
ENHANCED ISF TARGET	75	75	75	75	75	75	100	150	150	150	100	100	

TABLE 15.18

Scenario 8 Results
Black Canyon
Average Monthly Flow (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	300	423	300	468	1453	1718	2699	1851	1996	1098	891	522	1138
1953	379	300	356	849	523	439	665	441	1013	312	300	300	472
1954	300	309	300	917	1274	554	300	300	313	300	300	300	451
1955	300	476	483	481	447	404	300	300	300	300	300	300	364
1956	300	476	300	300	395	651	300	300	300	300	300	430	362
1957	300	300	300	300	1317	478	922	2179	3342	3563	2318	834	1346
1958	471	465	540	700	300	331	747	1540	4546	300	300	449	886
1959	300	319	300	572	984	1178	654	512	816	300	300	452	554
1960	858	926	300	300	300	300	542	300	775	300	300	356	471
1961	300	342	300	638	300	414	300	300	300	300	300	300	342
1962	300	300	300	300	820	1051	1035	300	889	459	300	353	530
1963	300	505	341	621	1044	1216	693	484	359	300	300	472	549
1964	813	549	300	300	300	300	300	409	998	419	300	514	458
1965	300	300	300	322	884	310	1321	1035	1237	1152	1567	1157	821
1966	749	467	479	414	556	573	870	770	515	310	300	424	535
1967	850	681	300	300	540	582	300	300	300	300	300	498	437
1968	733	559	300	300	300	300	300	300	1194	300	300	300	432
1969	300	300	300	300	1278	926	687	300	603	338	300	300	488
1970	334	300	300	1071	792	369	810	1863	2977	1369	777	1848	1065
1971	881	604	571	399	502	760	582	806	1150	354	387	508	626
1972	432	415	409	846	1107	721	637	549	707	300	300	454	569
1973	701	300	300	300	300	300	300	300	1454	450	300	300	442
1974	300	300	300	335	843	483	744	1176	761	300	300	447	521
1975	755	300	300	300	300	300	417	516	1289	1138	610	300	545
1976	372	300	300	546	816	746	761	702	704	300	300	500	526
1977	774	653	300	300	602	488	300	300	300	300	300	300	408
1978	300	300	300	300	300	1005	440	300	948	587	300	425	459
1979	410	300	300	300	674	724	1031	406	1531	674	466	335	593
1980	318	300	300	300	987	1024	1706	1477	2021	508	300	488	803
1981	318	300	300	300	526	547	441	351	579	389	389	300	392
1982	300	300	300	571	300	300	497	300	723	587	416	453	421
1983	390	445	325	300	303	318	404	1014	3644	3817	1579	508	1092
Average	461	410	334	448	667	619	891	687	1208	679	499	482	597
Std.Dev	213	149	74	206	354	338	485	536	1040	630	460	298	249
Maximum	881	926	571	1071	1453	1718	2699	2179	4546	3817	2318	1848	1346
Minimum	300	300	300	300	300	300	300	300	300	300	300	300	342
ENHANCED ISF TARGET	300	300	300	300	300	300	300	300	300	300	300	300	

TABLE 15.19

Scenario 8 Results
Blue Mesa Releases for Black Canyon Instream Flow
Values in AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	5431	0	5431
1954	0	0	0	0	0	0	17820	18414	0	937	18414	17820	73405
1955	14494	0	0	0	0	0	17820	18414	17708	1287	18414	17820	105957
1956	18414	0	0	0	0	0	17820	18414	17820	0	10540	0	83008
1957	18414	4859	0	0	0	0	0	0	0	0	0	0	23273
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	1114	8185	0	9299
1960	0	0	0	0	0	0	0	18414	0	3231	10540	0	32185
1961	0	0	0	0	0	0	17820	18414	17708	2509	10085	17820	84356
1962	5830	0	0	0	0	0	0	4002	0	0	0	0	9832
1963	0	0	0	0	0	0	0	0	0	1462	10187	0	11649
1964	0	0	0	0	0	6930	17820	0	0	0	1914	0	26664
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	9295	0	9295
1967	0	0	0	0	0	0	17820	18414	17820	459	9905	0	64418
1968	0	0	0	0	0	0	17820	11303	0	3129	1089	0	33341
1969	0	0	0	0	0	0	0	0	0	0	6725	0	6725
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	1794	10495	0	12289
1973	0	0	0	0	0	0	11942	0	0	0	0	0	11942
1974	0	0	0	0	0	0	0	0	0	4145	9850	0	13995
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	1814	10260	0	12074
1977	0	0	0	0	0	0	17820	18414	0	0	10985	11977	59196
1978	18414	17464	4137	0	0	0	0	18414	0	0	4129	0	62558
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	17820	17820
1982	18414	3251	0	0	0	0	0	2128	0	0	0	0	23793
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	2937	799	129	0	0	217	4828	5148	2221	884	5201	2602	24766
Std.Dev	6433	3158	720	0	0	1206	7780	7931	5875	1137	5648	6118	29360
Maximum	18414	17464	4137	0	0	6930	17820	18414	17820	4145	18414	17820	105957
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 15.20

Scenario 8 Results
Gunnison Tunnel Diversions
Values in AF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1952	68009	52688	58362	69666	62924	69666	67419	69666	67419	69666	69666	67419	802570
1953	69666	67419	69666	57390	48678	52971	44550	64817	64271	65799	69666	60900	735791
1954	61386	61717	61406	23595	8205	3253	43243	60705	59400	61380	61380	50906	558576
1955	29647	2673	1105	21606	2938	3253	42946	60705	59400	61380	61380	51737	398770
1956	31120	2673	14135	23940	38808	37258	42946	60705	62311	61380	69666	51678	496620
1957	35000	18473	12832	39251	62924	69666	67419	69666	67419	69666	69666	67419	649201
1958	69666	67419	69666	69666	62628	69666	67419	69666	67419	69666	69666	53935	806482
1959	69666	59281	59706	42720	23895	13565	43958	61380	59400	61380	69666	50906	615521
1960	29585	25423	16297	46085	18758	36590	57024	60705	65815	69666	69666	56074	551688
1961	60586	58865	60406	40081	15743	8777	42946	60705	59400	61380	69666	50906	589461
1962	29585	21109	60606	44888	62924	69666	67419	60705	67419	69666	69666	64687	688340
1963	69666	52985	66843	39406	21067	11294	43124	61380	59400	61380	69666	50906	607117
1964	30199	2673	14362	23141	14979	20606	42946	66290	62726	61380	69666	51282	460432
1965	63889	60280	59106	69666	62924	69666	67419	69666	67419	69666	69666	67419	796786
1966	69666	67419	69666	63528	52668	56285	43006	69175	60529	61380	69666	52094	735082
1967	29708	39263	61806	42498	29827	15529	46629	60705	59400	61380	69666	50906	587317
1968	33882	2673	15572	26101	36545	49873	49124	60705	67063	69666	69666	60134	541004
1969	63539	61080	60406	63106	62924	50270	64865	63486	67360	69666	69666	62128	758498
1970	69666	67419	68814	69666	62924	69666	67419	69666	67419	69666	69666	67419	819410
1971	69666	67419	69666	69666	62924	69666	67419	69666	67419	69666	69666	67419	820262
1972	69666	67419	69666	52234	41802	44685	43837	61380	59400	61380	69666	50906	692041
1973	39836	59080	59586	65045	60066	52628	54648	60974	67419	69666	69666	67419	726233
1974	62915	67419	60686	56224	47290	54076	47995	69666	64449	65001	69666	50906	716293
1975	34925	61280	61506	62006	48215	58697	67419	69605	67419	69666	69666	67419	738023
1976	58470	67419	58706	49534	37810	34618	43006	61380	59400	61380	69666	51084	650473
1977	30199	38432	58386	15990	998	3253	43065	60705	59400	51000	47000	18600	425028
1978	22900	2673	600	23446	29200	3253	43006	60705	66884	69666	69666	55836	447835
1979	56777	59280	58506	60306	62924	69666	67419	69666	67419	69666	69666	60410	771705
1980	63774	64033	62907	66077	62924	69666	67419	69666	67419	69666	69666	51143	784360
1981	59907	65934	64974	59106	50284	45851	58311	60275	50193	59968	59968	43124	675895
1982	43518	18473	13429	30997	48515	51402	53935	54383	60469	69666	69421	66053	580261
1983	66843	63083	69666	67600	62148	62915	63320	69666	67419	69666	69666	67419	799411
Average	51923	48871	50589	48632	42731	43703	54082	64320	63816	65865	66129	56393	656453
Std.Dev	16897	23987	23352	17256	20048	24021	10655	4450	4251	4750	4574	10215	123926
Maximum	69666	67419	69666	69666	62924	69666	67419	69666	67419	69666	69666	67419	820262
Minimum	22900	2673	600	15990	998	3253	42946	54383	50193	51000	47000	18600	398770

15.3.4.3 Export From Raised Taylor Park Reservoir Under UVWUA Storage Decree

In this alternative, Taylor Park Dam is assumed to be raised approximately twenty feet to elevation 9364.0 in order to increase the reservoir storage capacity to 186,000 af. It was assumed that the additional storage would be supported by a 1988 decree for 74,740 af (the existing UVWUA storage decree is for 111,260 af). The variation was evaluated in order to estimate what the maximum basin exports would be if Taylor Park Project is operated to minimize the occurrence of downstream releases which are in excess of the instream flow targets. This alternative was modeled, therefore, primarily to provide an indication of the maximum potential yield from Taylor Park Reservoir.

The model evaluated this alternative as described in the proceeding section except that the Taylor Park Exchange was not monitored. Introduction of the new, junior storage decree requires that administration of the exchange be modified and it was not deemed appropriate to attempt to define that modification at this time.

This alternative is represented by Scenarios 10, 11 and 12 which utilizes instream flow regimes I, II and III respectively. Table 15.21 summarizes the results of the three scenarios. The middle scenario, Scenario 11, is discussed in some detail below.

TABLE 15.21

Summary of Results

Scenario	Flow Regime	Target Export Rate (af/mo)	Average Annual Yield (af/yr)	Minimum Annual Yield (af/yr)	Min. Taylor Park Res. Storage (af/yr)
10	I	7,000	82,230	61,623	23,306
11	II	5,000	59,873	57,341	23,301
12	III	3,500	41,756	35,613	23,307

In the export scenarios listed in Table 15.20, the minimum annual yield typically occurs following the dry years of 1956 or 1977 and is the result of low reservoir storage in the early spring prior to runoff. This low reservoir storage causes exports to be curtailed according to the operating policies described above. Table 15.22 shows the export pattern represented in Scenario 11.

In Scenario 11, instream flow targets below Taylor Park dam are always met but are seldom exceeded. Table 15.23 lists the monthly instream flows below the dam for this scenario. Instream flows below the three new in-basin reservoirs are as depicted in Scenario 2B.

Taylor Park Reservoir operates at approximately the same level as in Scenario 1. Table 15.24 lists the start of month storage contents for Taylor Park Reservoir under Scenario 11.

The difference in Blue Mesa Reservoir operating levels between Scenarios 11 and 1 is depicted in Figure 15.12.

TABLE 15.22

EXPORTS FROM TAYLOR RESERVOIR
VALUES IN af

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tota
1952	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1953	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1954	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1955	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1956	5000	5000	5000	5000	5000	5000	3911	5000	5000	5000	5000	5000	5891
1957	5000	5000	5000	5000	5000	5000	4699	5000	5000	5000	5000	5000	5969
1958	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1959	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1960	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1961	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1962	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1963	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1964	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1965	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1966	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1967	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1968	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1969	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1970	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1971	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1972	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1973	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1974	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1975	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1976	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1977	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1978	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1979	5000	5000	5000	5000	5000	5000	2341	5000	5000	5000	5000	5000	5734
1980	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1981	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1982	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
1983	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
Average	5000	5000	5000	5000	5000	5000	4873	5000	5000	5000	5000	5000	5987
Std.Dev	0	0	0	0	0	0	495	0	0	0	0	0	49
Maximum	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	6000
Minimum	5000	5000	5000	5000	5000	5000	2341	5000	5000	5000	5000	5000	5734

TABLE 15.23

TAYLOR RIVER BELOW TAYLOR PARK DAM
AVERAGE MONTHLY FLOW (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	75	75	75	75	75	75	100	150	150	150	100	143	104
1953	75	75	75	75	75	75	100	150	150	150	100	100	100
1954	75	75	75	75	75	75	100	150	150	150	100	100	100
1955	75	75	75	75	75	75	100	150	150	150	100	100	100
1956	75	75	75	75	75	75	100	150	150	150	100	100	100
1957	75	75	75	75	75	75	100	150	150	150	100	100	100
1958	75	75	75	75	75	75	100	150	263	150	100	100	109
1959	75	75	75	75	75	75	100	150	150	150	100	100	100
1960	75	75	75	75	75	75	100	150	150	150	100	100	100
1961	75	75	75	75	75	75	100	150	150	150	100	100	100
1962	75	75	75	75	75	75	100	150	150	363	165	100	124
1963	75	75	75	75	75	75	100	150	150	150	100	100	100
1964	75	75	75	75	75	75	100	150	150	150	100	100	100
1965	75	75	75	75	75	75	100	150	150	181	100	100	103
1966	75	75	75	75	75	75	100	150	150	150	100	100	100
1967	75	75	75	75	75	75	100	150	150	150	100	100	100
1968	75	75	75	75	75	75	100	150	150	150	100	100	100
1969	75	75	75	75	75	75	100	150	150	224	100	100	106
1970	75	75	75	75	75	75	100	150	752	300	102	191	170
1971	102	75	75	75	75	75	100	150	524	311	115	100	148
1972	75	75	75	75	75	75	100	150	359	150	100	100	117
1973	75	75	75	75	75	75	100	150	150	240	100	100	108
1974	75	75	75	75	75	75	100	150	150	150	100	100	100
1975	75	75	75	75	75	75	100	150	150	150	100	100	100
1976	75	75	75	75	75	75	100	150	150	150	100	100	100
1977	75	75	75	75	75	75	100	150	150	150	100	100	100
1978	75	75	75	75	75	75	100	150	150	150	100	100	100
1979	75	75	75	75	75	75	100	150	150	150	100	100	100
1980	75	75	75	75	75	75	100	150	150	150	100	100	100
1981	75	75	75	75	75	75	100	150	150	150	100	100	100
1982	75	75	75	75	75	75	100	150	150	150	100	100	100
1983	75	75	75	75	75	75	100	150	150	150	100	100	100
Average	76	75	75	75	75	75	100	150	191	172	103	104	106
Std. Dev	5	0	0	0	0	0	0	0	126	54	11	17	15
Maximum	102	75	75	75	75	75	100	150	752	363	165	191	170
Minimum	75	75	75	75	75	75	100	150	150	150	100	100	100
CWCB DECREE	50	50	50	50	50	50	50	100	100	100	100	100	
ENHANCED ISF TARGET	75	75	75	75	75	75	100	150	150	150	100	100	

TABLE 15.24

TAYLOR PARK RESERVOIR CONTENTS
START OF MONTH IN af

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952	58600	53488	48633	43729	38725	33167	28051	25011	52690	114713	125967	128234
1953	122996	118216	112361	108157	103453	97895	92265	86387	91176	126726	129262	127027
1954	119153	112679	108124	102120	95916	90058	83829	84159	95847	101827	98724	91246
1955	81820	77580	71925	66221	60217	54059	47737	44644	53499	74095	71241	70101
1956	61304	56188	50633	45029	38925	33267	27251	23304	44794	78299	74038	70795
1957	64595	58076	52921	46917	41213	35555	29539	23301	28610	100603	160932	175517
1958	175258	172911	170756	167152	162948	158790	154247	145858	169139	186000	180702	176266
1959	168911	163174	157719	152215	146511	141053	135114	129861	131869	155095	150371	145397
1960	137193	134594	129939	124035	117331	111773	106140	106840	113804	150458	152537	149157
1961	140348	134846	129591	123987	118083	111725	105493	100098	112369	128472	121914	115698
1962	116136	117660	115305	111801	107497	103239	98008	102916	129469	172145	175319	169933
1963	163188	159756	155301	150297	144893	139635	134296	132941	146153	149441	140636	137379
1964	131087	125397	119942	113038	106134	99576	93245	86965	98750	113213	110787	108689
1965	101944	95987	90432	85328	80324	74866	68840	62103	75922	123301	157291	166289
1966	166145	166308	164053	161449	156745	152087	146746	145465	161353	170964	168399	164488
1967	158451	154026	148371	142767	137363	131905	126368	124529	137057	160042	163596	159994
1968	158661	154935	149080	144076	138872	133414	128277	121739	127977	157985	159946	167440
1969	163797	158566	154011	148407	143403	138545	132907	132953	154458	179466	186000	185350
1970	181578	180722	177267	172963	168759	163901	158257	149860	185923	186000	186000	186000
1971	186000	186000	183445	179141	175637	171279	167333	170305	175758	186000	186000	186000
1972	183126	177671	177216	173412	168908	163850	159606	159497	171064	186000	182700	177761
1973	173501	170956	166301	161597	156493	151135	145294	138921	149325	180342	186000	184051
1974	179282	174931	169076	163572	158668	153210	147268	143588	163276	175175	170702	164988
1975	156952	151230	145975	140071	133967	128009	121773	114849	118601	144158	159836	157940
1976	151614	146898	141743	135639	129335	123177	117142	113124	125472	145112	145706	143039
1977	138137	134237	128782	120778	113274	105916	98085	93998	93582	90180	80900	74348
1978	66344	60522	53867	47263	41459	35701	29684	25342	29947	67511	72762	68522
1979	59128	51817	45962	41158	37154	32296	25681	23306	41900	89788	105089	106399
1980	99056	93201	88846	83442	78338	74480	69953	62215	78731	133693	142904	138544
1981	131451	125461	120406	115802	110098	103640	97209	95522	94804	100288	94789	87716
1982	82292	77852	72997	67193	61689	55531	49209	44914	53569	87838	102042	104555
1983	104710	103449	99894	94890	89286	83828	77700	70248	73762	114155	132402	138053
Average	130711	126542	121902	116676	111301	105830	100080	96399	108771	135284	139859	138341
Std.Dev	40926	41828	42454	42808	43040	43239	43547	44045	45427	36967	36393	37514
Maximum	186000	186000	183445	179141	175637	171279	167333	170305	185923	186000	186000	186000
Minimum	58600	51817	45962	41158	37154	32296	25681	23301	28610	67511	71241	68522

15.3.4.4 Export From Existing Taylor Park Reservoir Under New Water Right

As an alternative to using existing basin water rights to support basin exports, the possibility of making such exports from Taylor Park Reservoir (same project concept as discussed in Section 15.3.4.2) using a new, junior water right decree was evaluated. Four scenarios were modeled assuming the use of new water rights to support transbasin diversions. Several applications for such rights are presently pending in water court. The alternatives examined using the basin model do not specifically represent any of these applications. Instead, the alternatives were structured to quantify the pattern of storable flow which would occur under different assumptions regarding instream flow water rights and reservoir operation to maintain these flows.

Important considerations in assessing the yield of a new water right include the effect of privately-held instream flow decrees on the Taylor River below Taylor Park Dam and the potential for full administration of the Aspinall Unit direct flow water rights by the State Engineer's office. The privately-held decrees for up to 445 cfs year-around have the potential to severely limit the yield of junior upstream appropriations or changes-of-use by senior upstream rights, regardless of whether replacement storage is constructed elsewhere in the basin. Scenario 13 assessed the storable flow yield of a new right for transbasin diversion assuming this privately held instream decree is maintained and exercised.

Potential increased demand by Aspinall Unit hydropower rights in the basin may result if these direct flow decrees are fully utilized to support power production. The hydrologic model was calibrated using only Aspinall Unit storage decrees to support the power generation. As discussed in Section 7.6.1, this was done to calibrate the model with historical reservoir operations. The study has not addressed full administration of these existing hydropower rights against upstream junior diversions. However, in the March 1989 issue of Colorado Stream Lines, Keith Kepler, Assistant Division IV Engineer stated that, in his opinion, export of water from Taylor Park would

not be feasible if hydroelectric power production rights are fully exercised in the future.

Scenarios 14, 15, and 16 examined the storable flow yield to new water rights assuming Taylor Park Reservoir is operated to maintain the three instream flow regimes discussed above. These scenarios all assume the privately held instream decree is not maintained. Such a situation could arise if, for example, the private decree were abandoned or failed to withstand a legal challenge.

Operation of Taylor Park Reservoir for instream flow maintenance also has the potential to affect storable flow yield of new water rights. For example, releases to instream flow may create storage capacity in the reservoir which would otherwise not exist; if the UVWUA storage decree has not been filled in this situation, it would call out a new transbasin diversion water right.

Taylor Park Reservoir was operated on the basis of storage targets and instream flow maintenance but without forecast operations which induce releases prior to runoff to minimize spills. Because the junior export right is available to take water which would otherwise spill, the forecast operation is no longer necessary. The storage targets used were the same as those incorporated in Scenario 1, with the target for the forecast period set to a full reservoir.

In all four scenarios, the three new in-basin reservoirs were assumed to be constructed. The performance of these new reservoirs was, in all cases, indistinguishable from the results obtained for Scenario 2B.

The results of the four export scenarios are summarized in Table 15.25.

TABLE 15.25

Summary of Export Scenarios
Using New Water Rights

Scenario	Flow Regime	Average Annual Storable Flow (af/yr)	Minimum Annual Storable Flow (af/yr)	Minimum Taylor Park Storage (af)
13	na[1]	7,234	0[2]	58,600
14	I	24,315	0[3]	58,600
15	II	21,559	0[3]	55,544
16	III	17,858	0[4]	35,881

Notes:
(1) Flow regime dictated by private instream flow decree
(2) Zero in 24 years of 32 year study period.
(3) Zero in 11 years of 32 year study period.
(4) Zero in 14 years of 32 year study period.

15.3.4.5 Summary of Hydrologic Modeling of Taylor Park Project

The yields of transbasin export projects were found to be dependent on: whether such exports were supported by existing or new water rights; the level of instream flow requirements in the Taylor River below Taylor Park dam; and on the maximum drawdown that would be allowed for Taylor Park Reservoir. Figure 15.14 summarizes the trade-off relationships between export yield and instream flow maintenance. The two basic institutional cases are presented, namely, use of existing or new water rights with the existing Taylor Park Reservoir but without Taylor River privately held instream flow decrees in place. Average storable flow yield under new rights, assuming the privately held instream decrees are in place, is also shown on Figure 15.14 as an isolated point.

Figure 15.15 presents the export yields available assuming an enlarged Taylor Park Reservoir and a combination of the existing UVWUA storage decree and a new (1988) storage decree for the enlargement. The export yield from the existing Taylor Park Reservoir available under the existing UVWUA storage decree is also shown on Figure 15.15 for comparison of the available yield from existing and enlarged Taylor Park Reservoir.

The storable flow available from an enlarged Taylor Reservoir under a new water right was not evaluated but it would be greater than the yields from existing Taylor Reservoir shown in Table 15.24.

It was decided to use instream flow regime II (42,000 af of average annual yield) as an example to derive the unit cost of yield for the Taylor Park Project. It should be noted, however, that a considerable amount of additional study is required before an instream flow regime is selected that would be acceptable from an environmental and recreational standpoint.

15.3.5 Value of Water

Many factors affect the value of water that might be delivered through potential transmountain diversion projects. The most obvious factor is the cost of alternative sources of water available to each potential east slope water user. If readily available supplies have already been developed by a particular east slope water user, then that user may be willing to pay a relatively high cost to obtain additional supplies.

Gunnison Basin water could be delivered to the Arkansas River or to the South Platte River. Therefore, this water could potentially be used by a broad range of end-users on the east slope. This study does not attempt to identify which of these potential users might utilize water from a Gunnison Basin transmountain diversion project. Therefore, the purpose of this assessment of the value of transmountain diversions is to provide a preliminary indication of whether east-slope diversions from the Gunnison

Basin merits further, more-detailed evaluation in any future phases of this study.

Based on a brief review of recent water transactions and estimated costs for projects currently being considered, front-range metropolitan areas are currently paying an up-front cost of $2000 to $10,000 per af of firm yield. This broad range in cost is largely attributable to variations in the definition of firm yield, the location of and alternatives available to specific water users, and the immediacy of the need for the water. Because transactions at either extreme of this cost range are relatively infrequent, it appears that a reasonable value of new sources of municipal water is in the range of $3000 to $9000 per af.

15.3.6 Conclusions

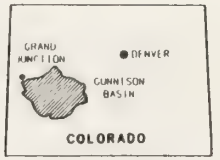
The Upper Taylor River Basin has the hydrologic potential to be the source of a transmountain diversion project that could deliver water to the South Platte River Basin or the Arkansas River Basin. The hydrologic yield of such projects depends on many technical and institutional considerations including, but not limited to, the water right used for the export and the instream flow requirements in the Taylor River drainage. A potential export project entails many conflicts with the holders of other water rights and with the operators of existing facilities.

The value of municipal water along the front range is estimated to be on the order of $3000 to $9000 per af. Using the Taylor Park Project as an example, the total capital cost ($300 million including east slope regulating storage) divided by an average annual yield of approximately 42,000 af results in a unit cost of about $7150 per af. This same project with the addition of 58,000 af of yield from the Blue Mesa pumping variation (100,000 af total project average annual yield) results in a unit cost of about $5310 per af based on a capital cost of about $531 million. These costs are within the range of costs being experienced by municipal and industrial users along the front range. The other alternative export projects investigated also appear

to be in this range of costs. It appears therefore that an out-of-basin water sales component may enhance the financial attractiveness of an in-basin development plan.

Further study would be required to compare alternative projects and to arrive at the optimum project configuration that will export water economically while providing adequate safeguards to the environment and to the recreational economy of the Gunnison River Basin. The results of this preliminary analysis indicate that such studies are warranted.

Map ID No.	Project Name	Map ID No.	Project Name
1	Oh-Be-Joyful	16	Silver Jack
2	Brush Creek	17	Halfway House No.1
3	Cement Creek No.2	18	Halfway House No.2
4	Cement Creek No.1	19	Needle Pt. No.1
5	Rocky Point No.1	20	Sheep Knob
6	Rocky Point No.2	21	Morrow Point No.1
7	Pitkin	22	Morrow Point No.2
8	Marshall Creek	23	Needle Pt. No.2
9	Needle Creek	24	Needle Pt. No.3
10	Cathedrel Creek	25	Curecanti Creek
11	Cebolla Creek No.1	26	Soap Mesa
12	Cebolla Creek No.2	27	Dry Gulch
13	Lake Fork No.1	28	Carpenter Ridge
14	Lake Fork No.2	29	Willow Creek
15	Horse Mesa	30	Curecanti



KEY MAP

LEGEND

- STUDY AREA BOUNDARY
- BASIN BOUNDARY BELOW STUDY AREA
- STREAMS, RIVERS
- STORAGE RESERVOIR
- MUNICIPALITY

SCALE IN MILES

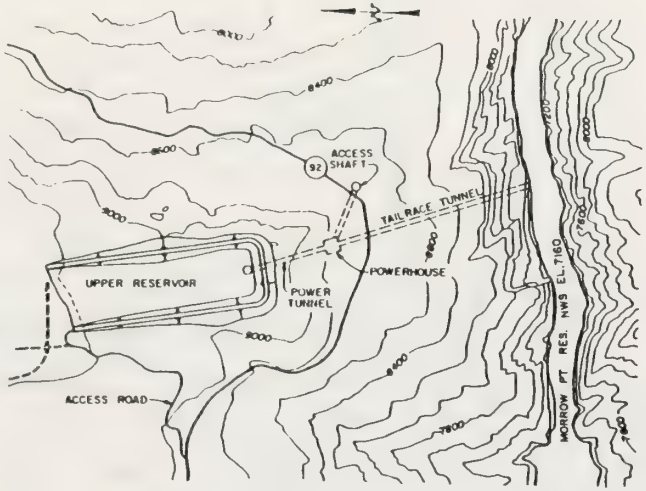
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

POTENTIAL PUMPED STORAGE SITES

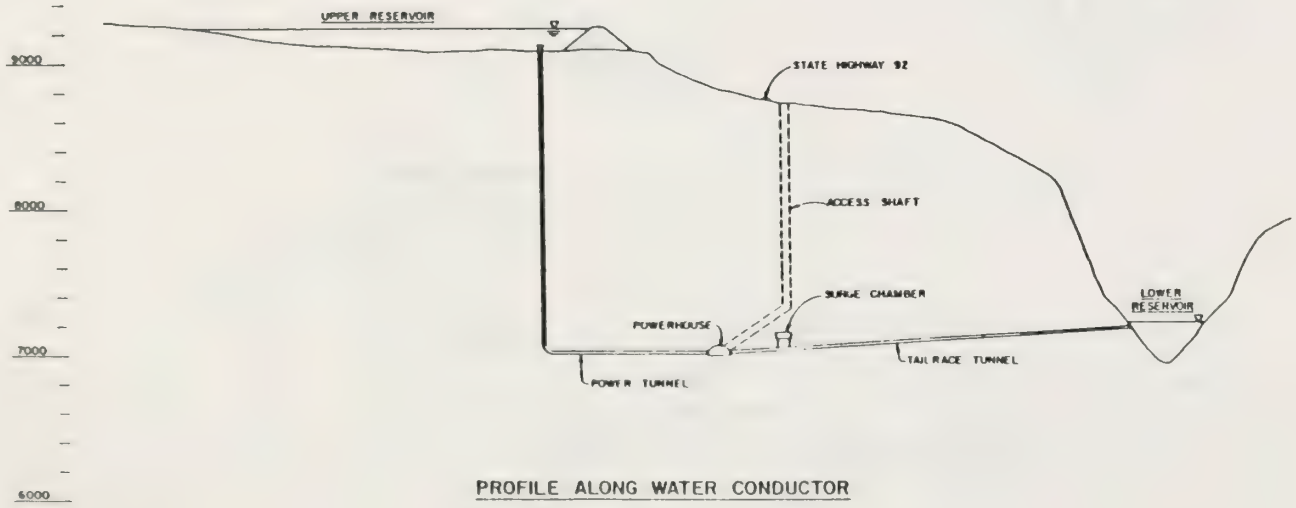
NBS ENGINEERING, INC

DATE April 1980 FIGURE 18.1



SITE PLAN

1000 0 1000
SCALE IN FEET



PROFILE ALONG WATER CONDUCTOR

COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

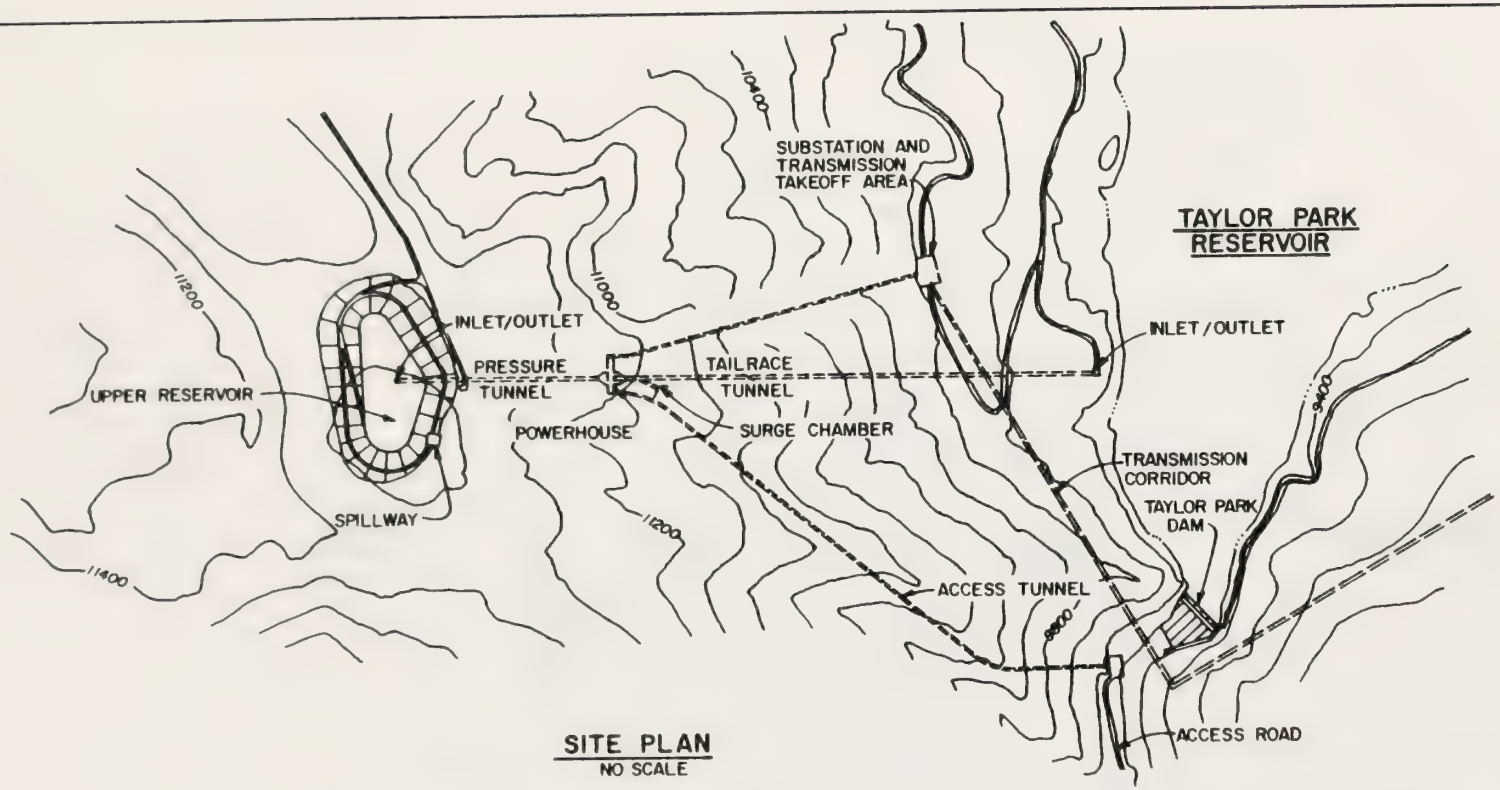
NEEDLE POINT NO. 3

PUMPED-STORAGE PROJECT

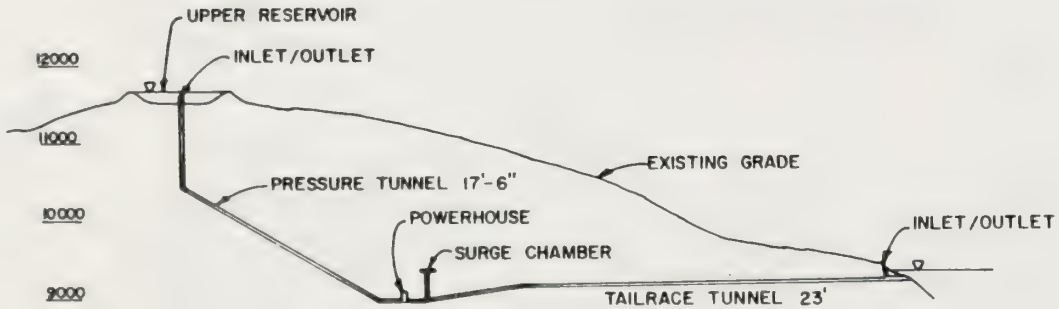
HDR ENGINEERING, INC.

CU Center For Economic Analysis · WBLA Inc
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE April 1989 FIGURE 15.2



SITE PLAN
NO SCALE



PROFILE ALONG POWER TUNNEL

NOTE: DATA PRESENTED HEREIN TAKEN FROM APPLICATION FOR MAJOR UNCONSTRUCTED PROJECT FOR THE ROCKY POINT PUMPED STORAGE PROJECT (FERC PROJECT NO. 7802) PROPOSED BY NATURAL ENERGY RESOURCES COMPANY WITH THE EXCEPTION OF THE UPPER RESERVOIR WHICH IS SHOWN ENLARGED.

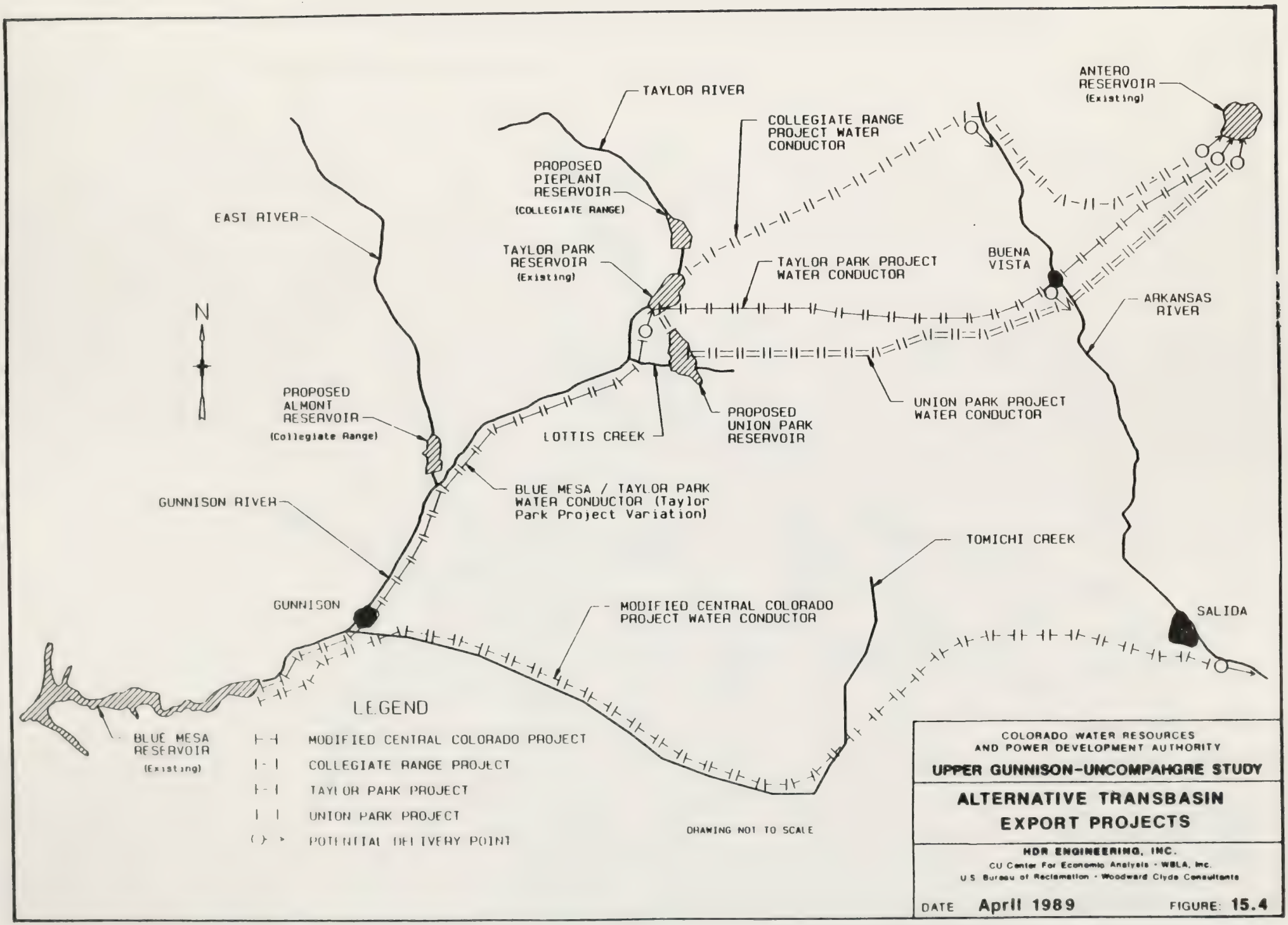
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

ROCKY POINT PUMPED-STORAGE PROJECT

HDR ENGINEERING, INC.
CU Center For Economic Analysis · WBLA, Inc
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE April 1989 FIGURE 15.3


TAYLOR RIVER
ANTERO RESERVOIR
(Existing)
COLLEGIATE RANGE PROJECT WATER CONDUCTOR
PROPOSED PIEPLANT RESERVOIR
(COLLEGIATE RANGE)
EAST RIVER
TAYLOR PARK RESERVOIR
(Existing)
TAYLOR PARK PROJECT WATER CONDUCTOR
BUENA VISTA
ARKANSAS RIVER
N
PROPOSED ALMONT RESERVOIR
(Collegiate Range)
LOTTIS CREEK
PROPOSED UNION PARK RESERVOIR
UNION PARK PROJECT WATER CONDUCTOR
BLUE MESA / TAYLOR PARK WATER CONDUCTOR (Taylor Park Project Variation)
GUNNISON RIVER
TOMICHI CREEK
GUNNISON
MODIFIED CENTRAL COLORADO PROJECT WATER CONDUCTOR
SALIDA
LEGEND
MODIFIED CENTRAL COLORADO PROJECT
COLLEGIATE RANGE PROJECT
TAYLOR PARK PROJECT
UNION PARK PROJECT
POTENTIAL DELIVERY POINT
BLUE MESA RESERVOIR
(Existing)
DRAWING NOT TO SCALE
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY
UPPER GUNNISON-UNCOMPAHGRE STUDY
ALTERNATIVE TRANSBASIN EXPORT PROJECTS
HDR ENGINEERING, INC.
CU Center For Economic Analysis - WBLA, Inc.
U.S. Bureau of Reclamation - Woodward Clyde Consultants
DATE April 1989
FIGURE: 15.4

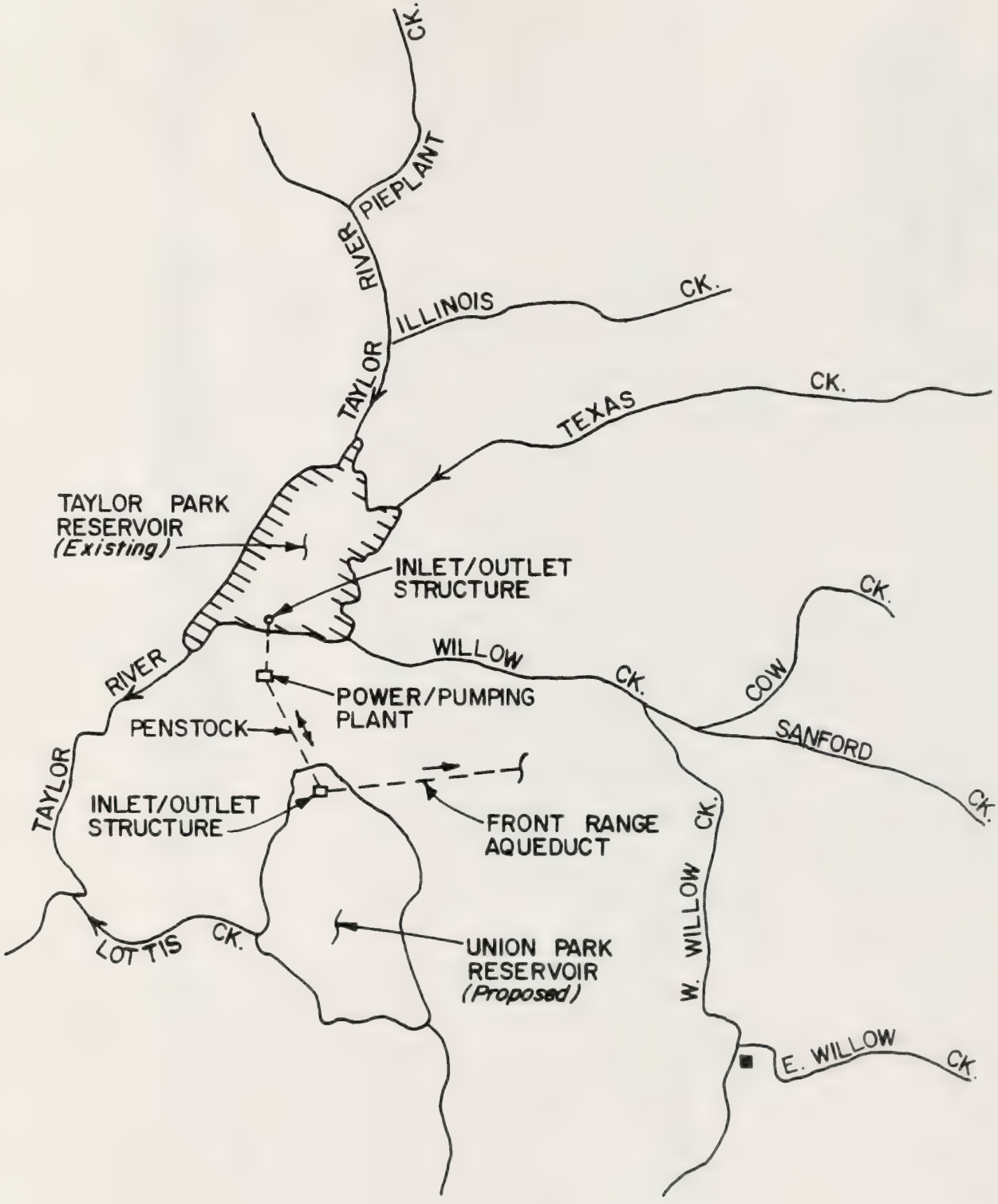
COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

COLLEGIATE RANGE PROJECT
WATER COLLECTION SYSTEM

HDR ENGINEERING, INC.
CU Center For Economic Analysis - WBLA, Inc.
U.S. Bureau of Reclamation - Woodward Clyde Consultants

DATE **April 1989** FIGURE **15.5**



COLORADO WATER RESOURCES
AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

GENERAL PLAN
UNION PARK PROJECT

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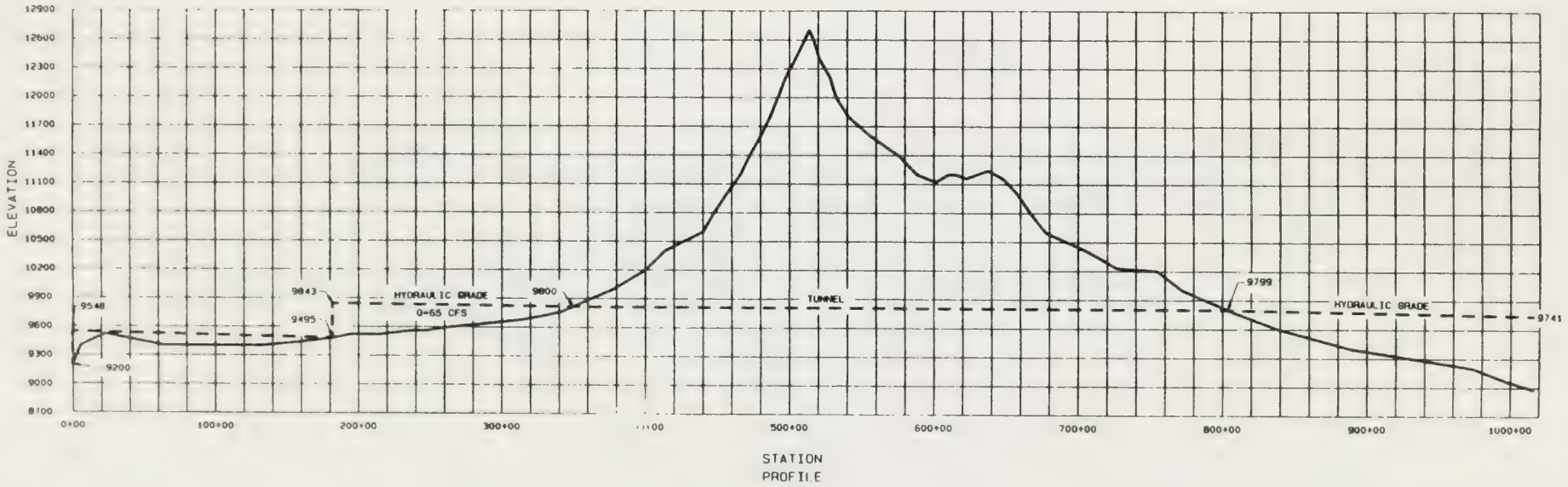
U.S. Bureau of Reclamation · Woodward Clyde Consultants

DATE: **April 1989** FIGURE: **15.6**



COLORADO WATER RESOURCES
AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

TAYLOR PARK PROJECT

SHEET 1 OF 2

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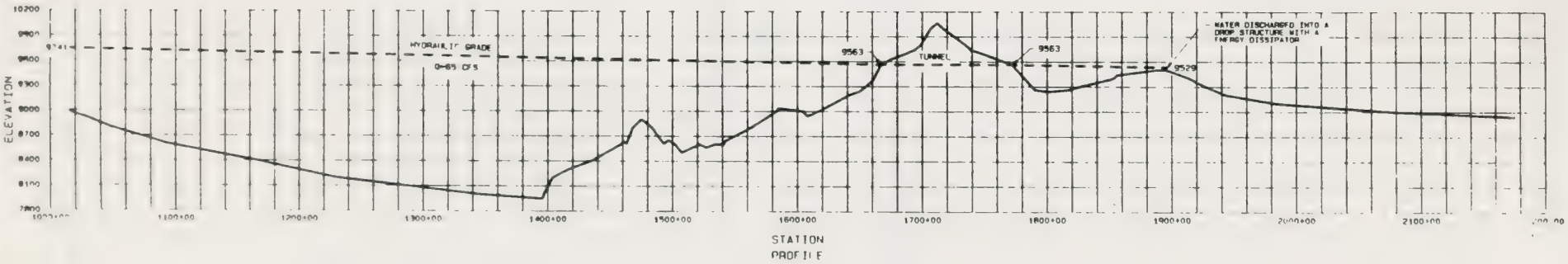
DATE: **April 1989** FIGURE: **15.7**



COLORADO WATER RESOURCES AND POWER DEVELOPMENT AUTHORITY

UPPER GUNNISON-UNCOMPAHGRE STUDY

TAYLOR PARK PROJECT
SHEET 2 OF 2

HDR ENGINEERING, INC.
CU Center For Economic Analysis • WBLA, Inc.
U.S. Bureau of Reclamation • Woodward Clyde Consultants

DATE: **April 1989** FIGURE **15.7**

FIGURE 15.8

TAYLOR PARK RESERVOIR LEVEL
Scenario 8

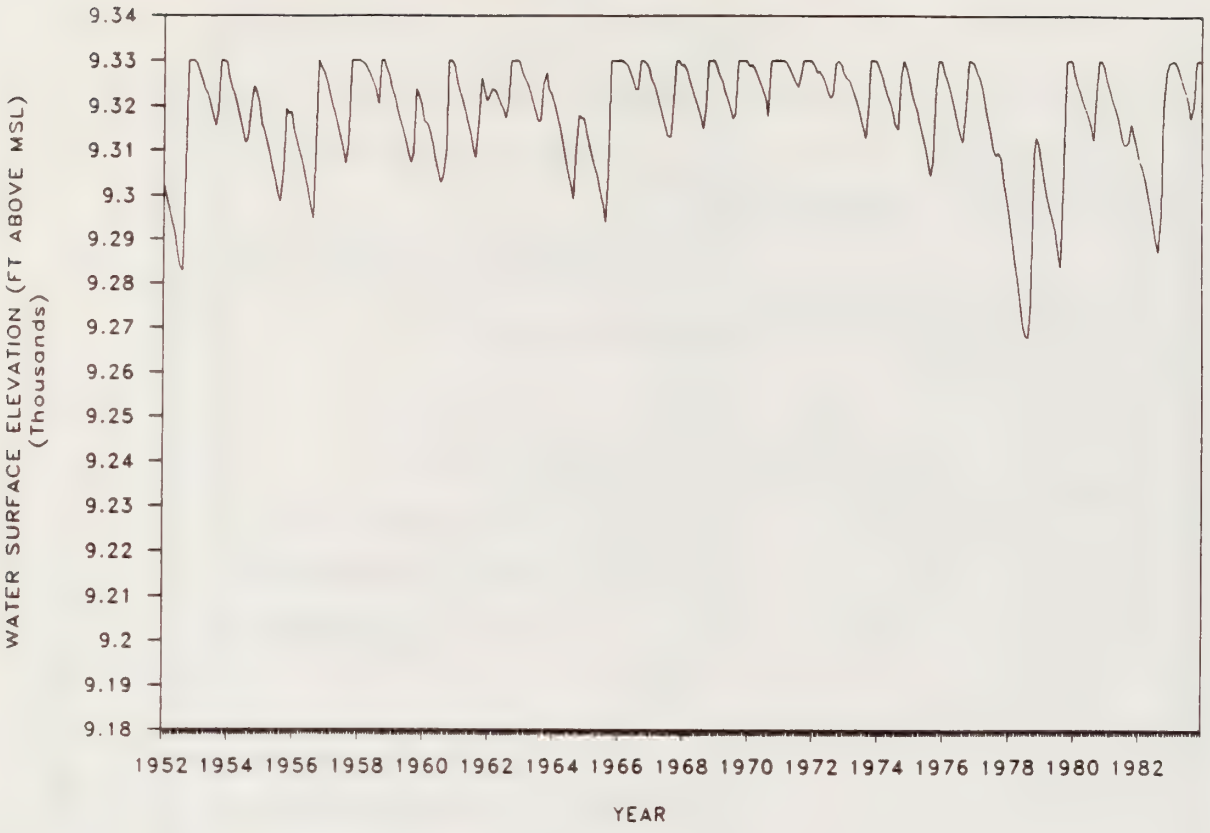


FIGURE 15.9

BLUE MESA RESERVOIR LEVEL
Scenario 8

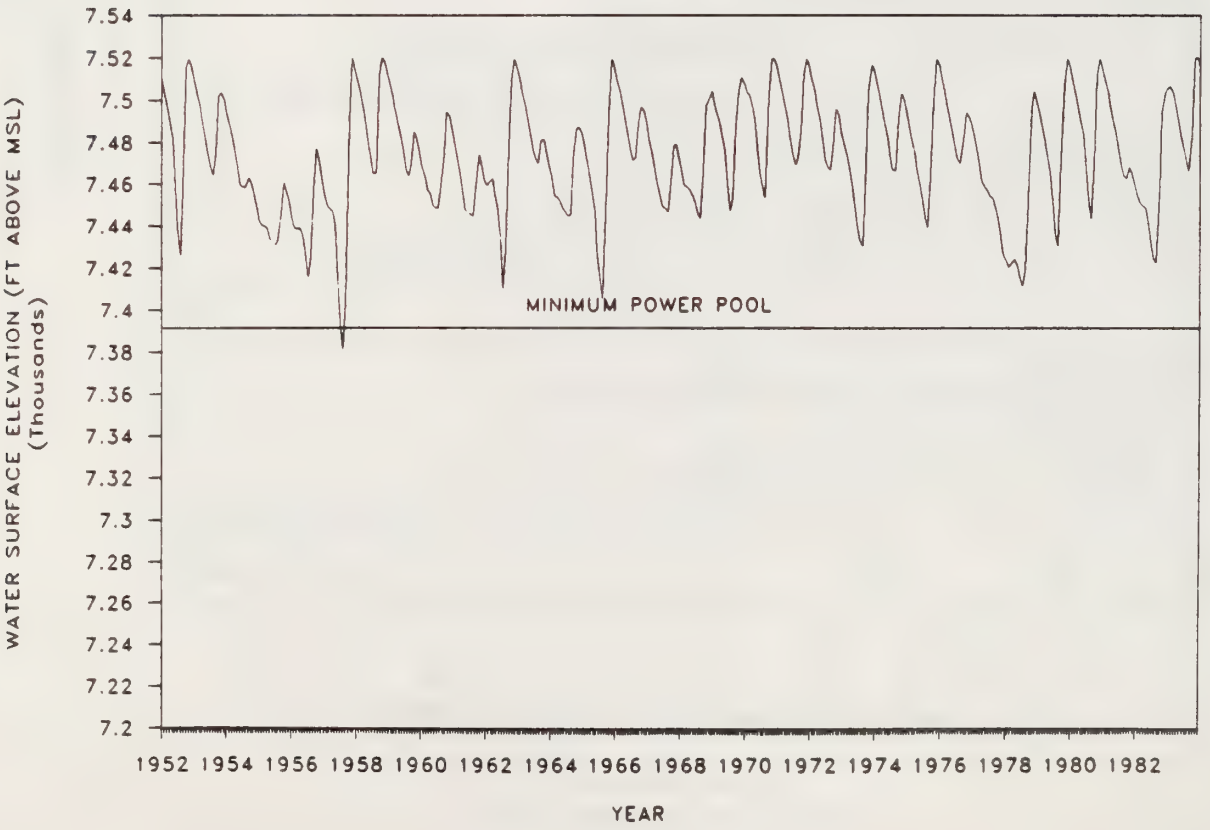


FIGURE 15.10

BLUE MESA RESERVOIR LEVEL
No-Action Versus Scenario 8

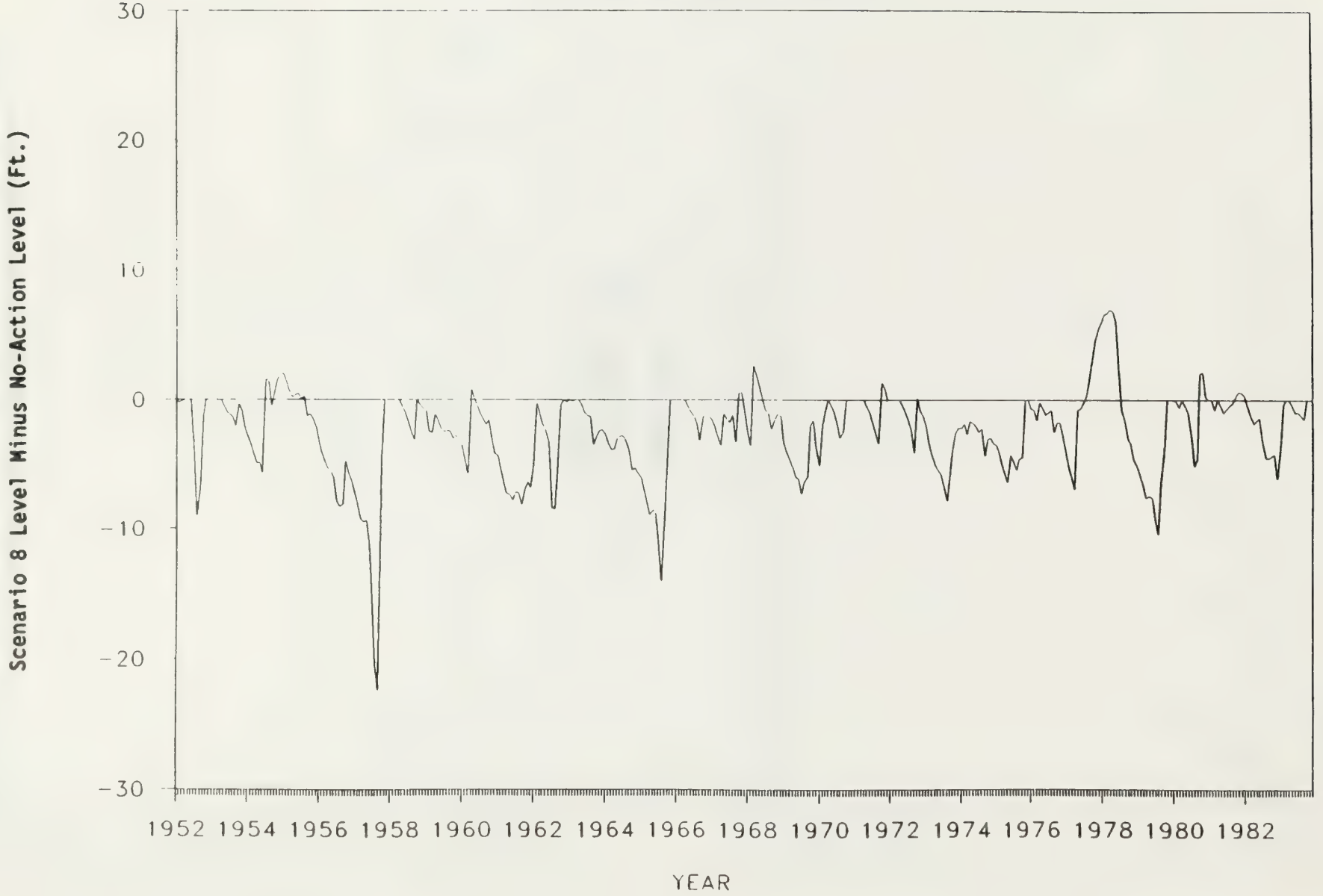


FIGURE 15.11

TAYLOR PARK EXCHANGE ACCOUNT STATUS
Scenario 8

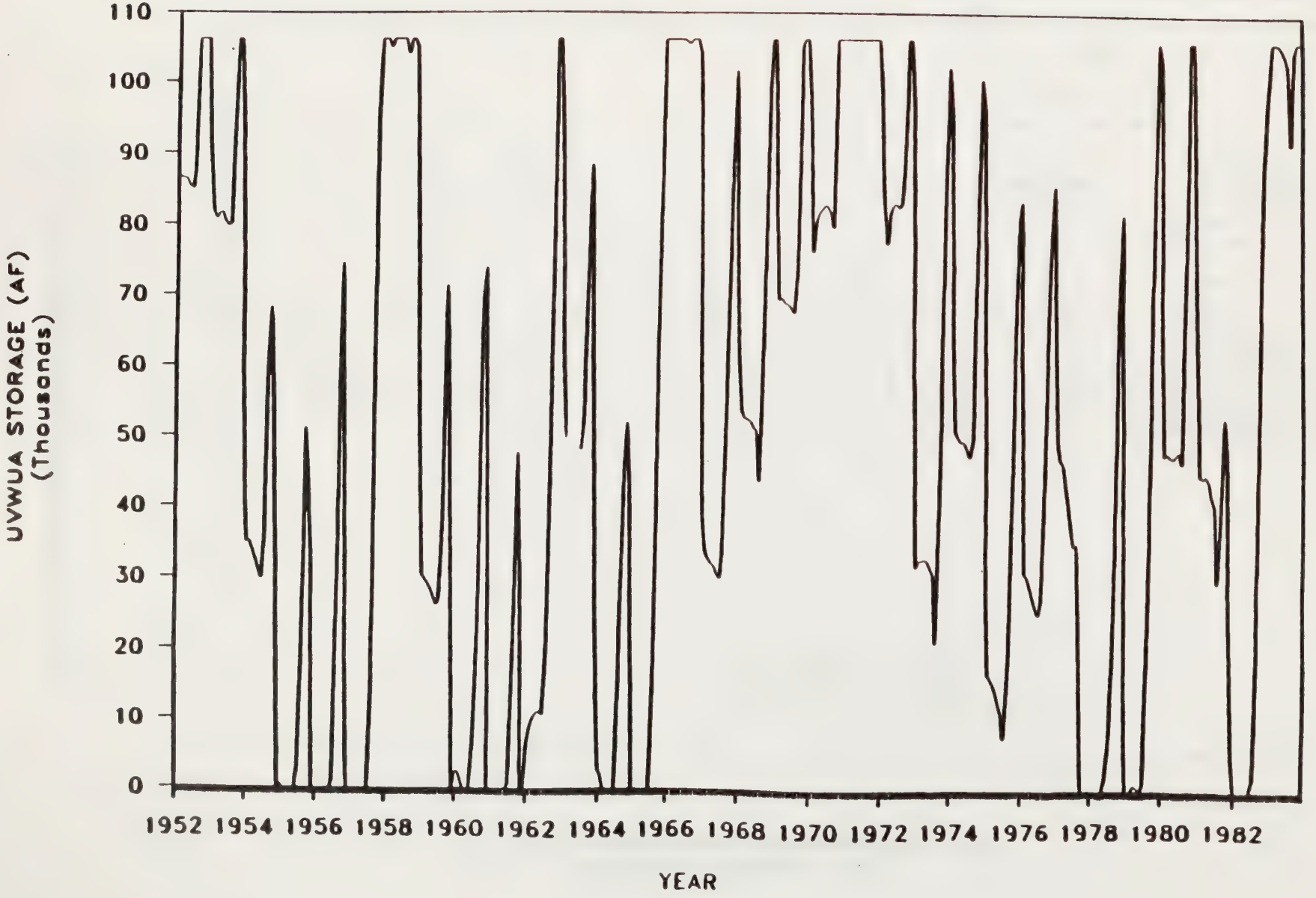


FIGURE 15.12

BLUE MESA RESERVOIR LEVEL
No-Action versus Scenario 11

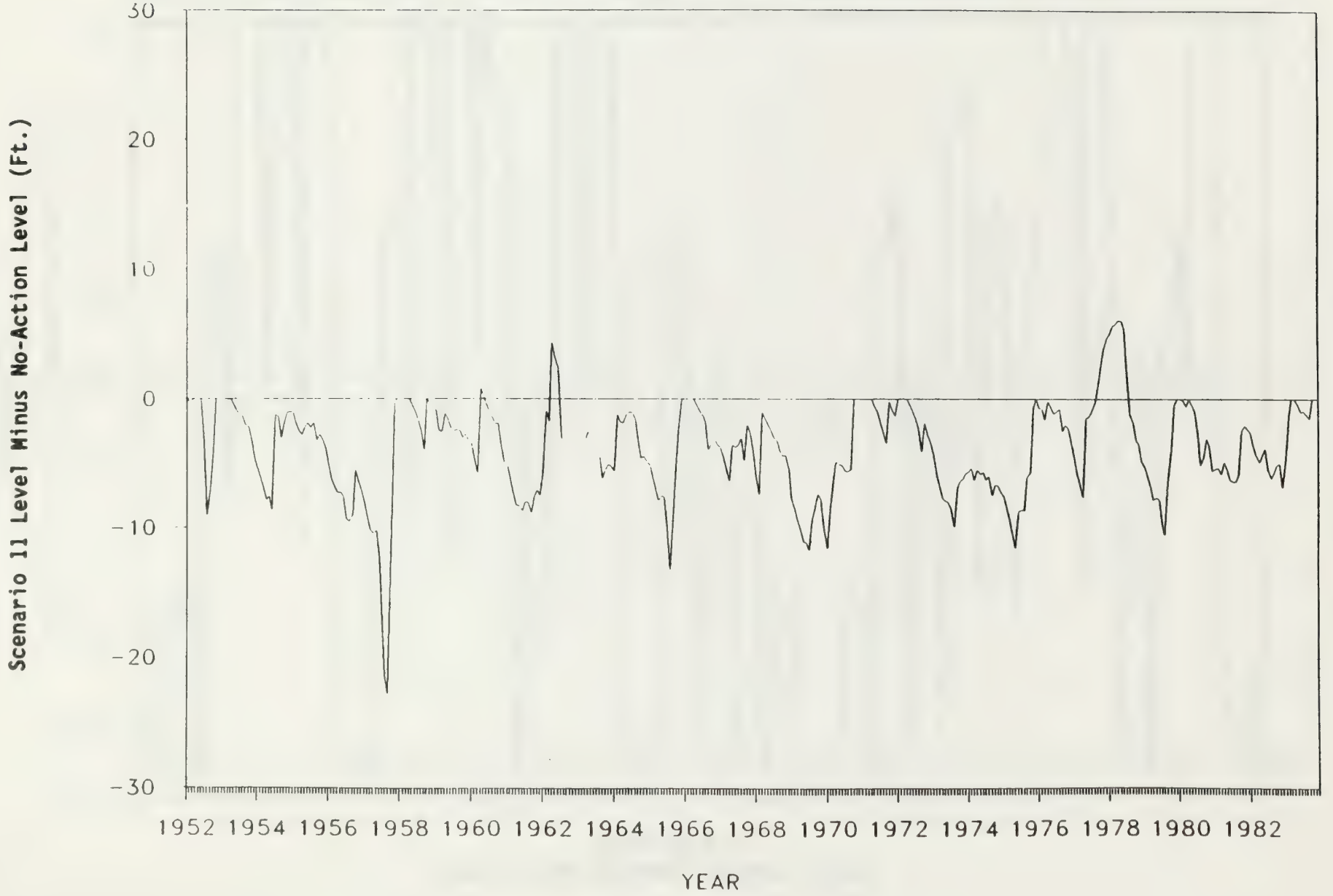
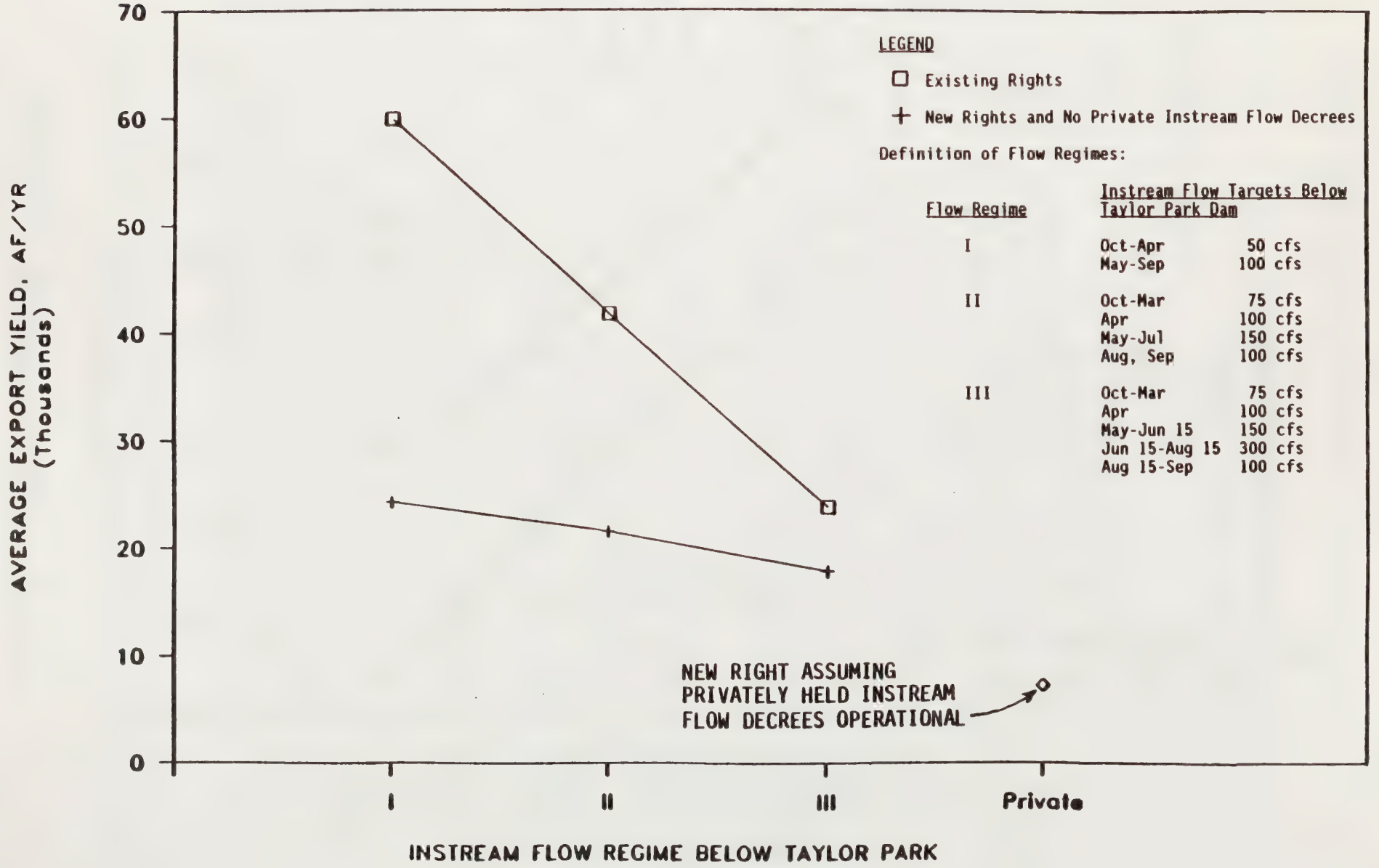


FIGURE 15.13

EXPORT YIELD VERSUS INSTREAM FLOW
Existing and New Water Rights

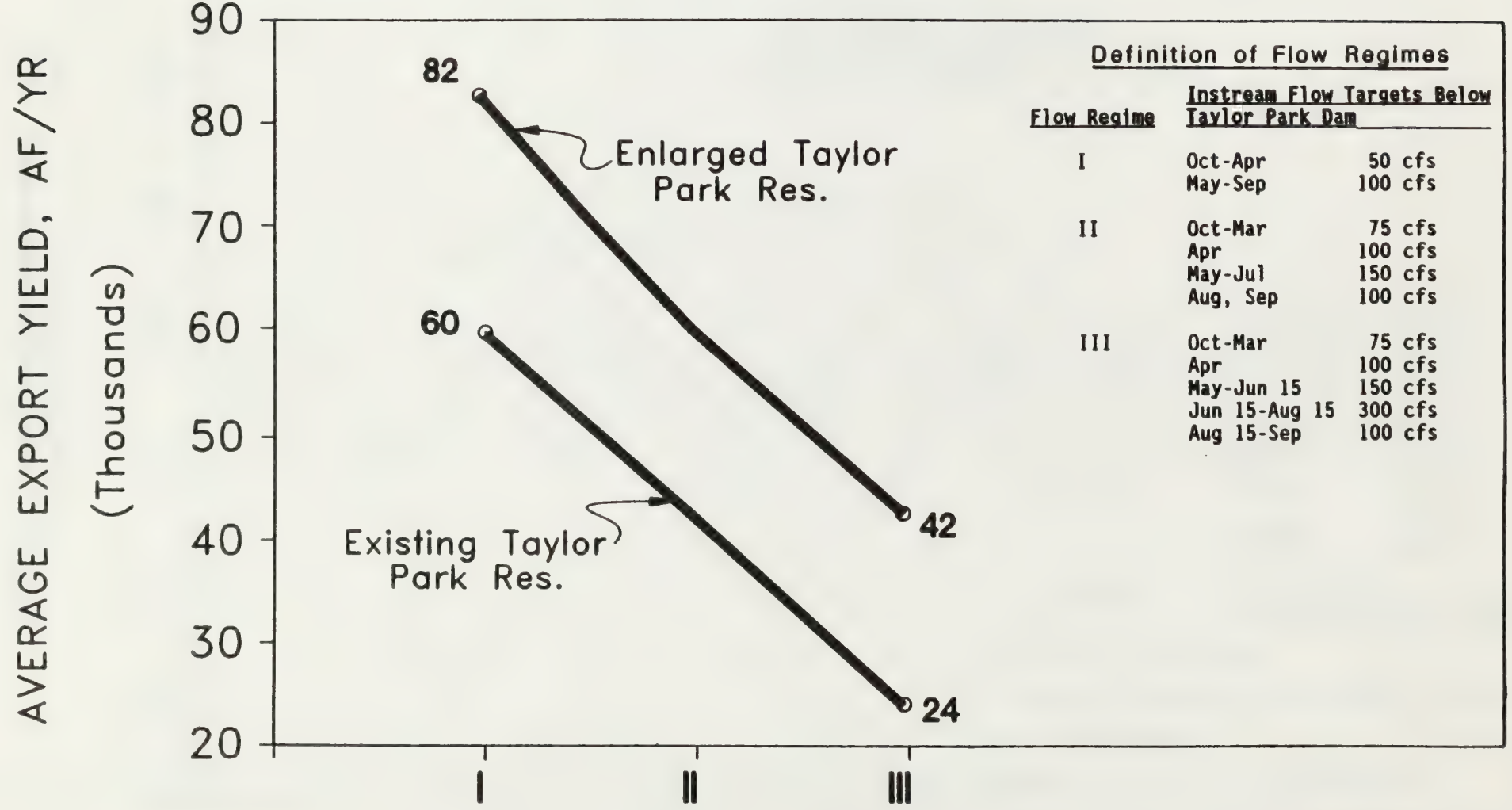


Definition of Flow Regimes:

Flow Regime	Instream Flow Targets Below Taylor Park Dam	
I	Oct-Apr	50 cfs
	May-Sep	100 cfs
II	Oct-Mar	75 cfs
	Apr	100 cfs
	May-Jul	150 cfs
	Aug, Sep	100 cfs
III	Oct-Mar	75 cfs
	Apr	100 cfs
	May-Jun 15	150 cfs
	Jun 15-Aug 15	300 cfs
	Aug 15-Sep	100 cfs

Figure 15.14

TAYLOR PARK PROJECT
EXPORT YIELD VS. INSTREAM FLOW
EXISTING AND ENLARGED



Definition of Flow Regimes

Flow Regime	Instream Flow Targets Below Taylor Park Dam	
I	Oct-Apr	50 cfs
	May-Sep	100 cfs
II	Oct-Mar	75 cfs
	Apr	100 cfs
	May-Jul	150 cfs
	Aug, Sep	100 cfs
III	Oct-Mar	75 cfs
	Apr	100 cfs
	May-Jun 15	150 cfs
	Jun 15-Aug 15	300 cfs
	Aug 15-Sep	100 cfs

16.0 ENVIRONMENTAL CONSIDERATIONS

16.1 ENVIRONMENTAL IMPACTS

16.1.1 General

This chapter presents appraisal level evaluations of environmental effects that may result from the construction and operation of the potential alternative plans and financing mechanisms evaluated during the study.

The climate, topography, vegetation, agricultural crops, and fish and wildlife resources vary considerably in the study area. Elevations range from approximately 6,000 feet in the Uncompahgre Valley to 14,000 feet along the Continental Divide. According to climatic differences, vegetation types range from alpine conditions to spruce-fir forests to semi-desert shrubland.

Throughout the area, streams and rivers have historically been developed to provide irrigation water and to produce hydropower. Most of the water is used in-basin. Despite a high degree of development of water resources in the area, relatively large areas in upper elevations remain pristine as evidenced by the number of wilderness areas and roadless areas in the basin.

The Gunnison River drainage, upstream from the Aspinall Unit is noted for its fishing, hunting, scenery, wildlife viewing, and general recreation uses. Historically ranching and mining have been the major economic contributors to the area; however, the importance of recreation and related industries has steadily increased over the years. Task Memorandum No. 4 entitled "Recreation and Environmental Enhancement Opportunities" prepared as part of this study, contains discussions on existing fishery and recreation resources and potential opportunities to enhance these resources.

Reservoir sites, recreation plans, transmountain diversion plans, and pumped-storage plans discussed in this report would affect existing

environmental conditions by altering streamflows, changing land use, and increasing recreation use.

In-basin structural components are discussed first and the plans that contain these components are discussed next. Finally, the potential pumped-storage and transmountain diversion projects considered are discussed.

16.1.2 In-Basin Reservoirs

A total of five in-basin reservoirs survived the screening process; one in the Ohio Creek basin, two in the Cochetopa basin, and two in the Tomichi basin. The two Cochetopa sites are fairly close to one another (less than seven miles apart) although on different tributaries. The Tomichi sites are on the mainstem of Upper Tomichi Creek within a four-mile stream reach. One reservoir has been selected from each basin for evaluation and discussion in order to illustrate the types of impacts that are expected to occur at any of the sites.

16.1.2.1 Pauline Reservoir

Pauline Dam and Reservoir site is located on Pauline Creek 4.2 miles upstream from the confluence of Pauline and Cochetopa Creeks. The site is located within the Gunnison National Forest and the primary land uses are livestock grazing, recreation, and fish and wildlife. The reservoir site is approximately 210 acres in area and is dominated primarily by the meadow-type vegetation.

Pauline Creek is perennial with an average flow of 9 cfs. Average monthly flows range from 26 cfs in June to 4 cfs in winter months. The state of Colorado has appropriated an instream flow water right of 3.5 cfs at the reservoir site.

The location is over 9,000 feet in elevation and provides summer and fall range for mule deer and elk, but is located too high for winter range during

most winters. Bighorn sheep occur in the mountains to the south of the site. The creek itself is an excellent self-supporting brook trout fishery. Also, brown and rainbow trout have been collected in the lower reaches of Pauline Creek. There are no apparent water quality problems at the site.

Construction of the reservoir would result in the inundation of approximately 210 acres of primarily meadow-type vegetation. The 1.1 mile of gravel road relocation and borrow areas for the dam would require additional acreage. Increased human activity during construction and during the summer recreation seasons following construction would reduce use of the area by deer and elk; however, summer range is probably not limiting big game populations in this area.

The 10,000 af reservoir should support only a fair fishery. Water quality conditions would be good but reservoir fluctuations would be extreme as shown previously in Figure 13.3. Stocking of the reservoir would be required to maintain any level of fishing success because spawning habitat would be limited.

Water releases from the reservoir would be made to honor existing water rights, enhance instream flows, and supplement irrigation supplies downstream. Generally excellent fisheries develop downstream from reservoirs if adequate water releases and water quality conditions are maintained. Spring runoff flows would be moderated although periodic reservoir spills during high runoff years would provide occasional scouring. Summer flows would be increased and winter flows maintained. This combination would probably improve the fishery in the 4.2-mile reach to Cochetopa Creek. Minimum streamflows in Cochetopa Creek would also be improved significantly over the No-Action Alternative (Scenario 1) with this reservoir in place but significant enhancement above the present CWCB instream flow decree is not possible due to insufficient hydrologic yield at the reservoir site.

Recreation at the site would include fishing and camping; however, reservoir fluctuations may limit both the quality and quantity of recreation use.

16.1.2.2 Sargents No. 3 Reservoir

Sargents No. 3 Dam and Reservoir site is located on Tomichi Creek approximately 31 miles east of the town of Gunnison and approximately 1 mile upstream from the Marshall Creek-Tomichi Creek confluence. The site is primarily private land but includes some Gunnison National Forest land and some state (school section) land. The reservoir would be approximately 475 acres in area. Primary land uses are irrigated agriculture, wildlife winter range, livestock grazing, and transportation. Primary vegetation types are irrigated hay, riparian, and sagebrush.

Tomichi Creek is a perennial stream at the reservoir site and has an average annual flow of 47 cfs (as measured above Razor Creek). Average monthly flows range from approximately 25 cfs in winter months to approximately 120 cfs during June. Maximum and minimum average monthly flows have ranged from over 450 cfs to near zero cfs. The CWCB has appropriated an instream flow water right of 9 cfs at the reservoir site.

The reservoir site is at an elevation of approximately 8,500 feet and is near the upper end of an area considered by the DOW to be a critical winter range for mule deer. South facing slopes in the basin and immediate area are good elk winter range and summer use of the meadows by both deer and elk is common. There is also a small population of sage grouse in the area.

The dominant salmonid species in Tomichi Creek is brown trout; long-nose and white suckers are abundant. Brook and rainbow trout are also present. Limiting factors for fisheries at the site and downstream on Tomichi Creek are reported to include siltation, warm summer water temperatures, lack of streamside vegetation, and fluctuating flows due to natural runoff conditions

and irrigation diversions. These conditions are more evident in lower reaches of Tomichi Creek downstream from the Sargents No. 3 site.

Construction of the reservoir would result in the inundation of approximately 475 acres of primarily irrigated agriculture-grazing land. Relocation of U.S. Highway 50 for 4.3 miles around the west and north sides of the reservoir would utilize additional acreage. There would be a loss of summer and winter range for big game. Because winter ranges are reported by the DOW to limit deer and elk populations in the area, these changes may be expected to reduce big game populations although it is not possible at this level of study to estimate the degree to which this would occur. The reservoir would have some effect on big game migrations but is probably not large enough to disrupt migration patterns.

The proposed 25,000 af reservoir should develop into a good fishery. The reservoir would have a minimum pool of 2,500 af, but this minimum would be reached very infrequently. The preliminary operation plan indicates relatively small fluctuations except in dry years as shown previously in Figure 13.2. The reservoir would require stocking to maintain an acceptable level of fishing.

Flows downstream on Tomichi Creek would be stabilized to some extent and the reservoir would tend to trap sediments. Table 16.1 summarizes pre- and post-reservoir average monthly flows above Razor Creek.

TABLE 16.1

Monthly Flows (cfs) on Tomichi Creek
Above Razor Creek

	Flow without Reservoir		Flow with Reservoir	
Month	Average	Minimum	Average	Minimum
January	25	15	23	20
February	26	13	24	20
March	33	20	27	18
April	61	15	47	31
May	126	0	110	31
June	121	0	119	31
July	41	0	53	33
August	25	0	38	31
September	29	5	40	26
October	35	13	29	20
November	28	19	24	20
December	25	15	23	20

The primary benefit from a fishery standpoint would be to increase minimum flows in the summer. Average monthly flows as measured above Razor Creek are near zero in dry summers under the present conditions. Operation of Sargents No. 3 Reservoir would increase these minimums to around 30 cfs. On the average, 2,400 acre-feet of water would be released annually from the reservoir for flow enhancement.

Because of the reservoir's location on a paved highway and because of its relatively good operational characteristics, it would have excellent potential as a flatwater recreation area.

16.1.2.3 Castleton Reservoir

Castleton Dam and Reservoir site is located on Castle Creek 2.7 miles upstream of the creek's confluence with Ohio Creek. The site is located within the Gunnison National Forest and the primary land uses are recreation and livestock grazing. The proposed reservoir site is approximately 286 acres in area and is dominated primarily by the meadow-type vegetation.

Castle Creek is a perennial stream with an average flow of approximately 30 cfs. The CWCB has appropriated an instream flow right of 7 cfs at this site. Castle Creek flows into Ohio Creek, a stream that has been reported to have been a good fishery in the past but is of limited value at the present time due to low summer flows, high spring flows, and lack of riparian vegetation. Castle Creek is a good brook trout fishery and there are beaver ponds in the drainage. Brown trout are also reported.

The location is over 9,200 feet in elevation and provides summer and fall range for mule deer and elk, but is located above good winter ranges.

Construction of Castleton Reservoir would result in the inundation of approximately 290 acres of primarily meadow-type vegetation. There would be a loss of big game summer range, but winter ranges would not be affected.

The 20,000 af reservoir should develop into a good fishery. The reservoir would have a minimum pool of 2,000 af and would not have major fluctuations. Figure 13.1 demonstrates the expected fluctuations. To maintain an acceptable level of fishing, stocking would be necessary.

Flows in Castle Creek would be moderated with generally lower peak flows and higher minimum flows. Operation studies indicate that average monthly minimum flows would increase to at least 10 cfs. On the average, 2,400 acre-feet of water would be released annually to increase minimum flows in Castle Creek and downstream in Ohio Creek. Minimum average monthly flows at the mouth of Ohio Creek would increase from zero (June and July) to an

estimated 29 cfs. These flow changes would be beneficial to Ohio Creek and probably to the lower reaches of Castle Creek.

The reservoir would be located approximately 1.5 miles from the boundary of the West Elk Wilderness Area. A hiking trail would require relocation around the upper end of the reservoir. Because of its location and operational aspects, Castleton Reservoir should have good recreation potential.

16.1.3 Impacts of Alternative Plans

Six alternative plans have been identified with the intent of covering a broad spectrum of development possibilities. These plans are described in Chapter 13.0 and the results of evaluating the plans are also discussed in that Chapter. The six plans are described in general terms as follows:

Alternative No. 1 - 17 non-structural recreation components
Alternative No. 2 - Three reservoirs, one each in the Ohio, Tomichi and Cochetopa Creek basins.
Alternative No. 3 - Combination of Alternatives 1 and 2
Alternative No. 4 - Three reservoirs plus ten selected recreation components
Alternative No. 5 - Two reservoirs, one each in Ohio and Tomichi Creek basins, plus ten selected recreation components
Alternative No. 6 - One reservoir in the Tomichi Creek basin plus ten selected recreation components

Alternative No. 1 is non-structural and is considered a recreational enhancement plan. It is not totally non-structural in the strict sense of the term as it does include construction of certain recreation facilities such as campgrounds and trails, river recreation access, and provisions for improved fishing access.

The impacts of Alternative No. 1 would primarily be to increase both the quantity and quality of recreation in the Gunnison River Basin. During design phases and final site selection, concerns such as increased human use associated with these plans would be addressed. The suggested locations for these improvements are in areas that have good access and do not have pristine or wilderness characteristics. The primary concern which must be addressed in future phases of study is the ecological impacts associated with the recommended development and with the increased human use within the Study Area.

Alternative No. 2, consisting of the three in-basin reservoirs was discussed in Section 16.1.2 of this report.

Alternative No. 3 would combine Alternative No. 1 with the three in-basin reservoirs discussed above in 16.1.2. Recreation components would remain the same. As discussed previously the reservoir sites have both positive and negative aspects from a fishery, wildlife, recreation, and environmental standpoint.

Alternative No. 4 combines a portion of Alternative No. 1 with the three in-basin reservoirs. Recreation components have been reduced, however, to reduce total costs. For example the number of campsites has been decreased. Environmental impacts of this alternative would be very similar to those of Alternative No. 3 and recreation benefits would be reduced.

Alternative No. 5 is similar to 4 except Pauline Reservoir is not included. The Pauline site has been discussed as having a relatively high impact on stream fisheries and having relatively low recreation potential. Therefore this plan should have similar benefits and fewer environmental problems than Alternative No. 4. The loss of the stream fishery at the Pauline Reservoir site would not occur.

Alternative No. 6 is similar to 4 except only one in-basin reservoir, Sargents No. 3, would be constructed. Fishery and recreation benefits associated with Castleton would be foregone.

16.1.4 Transmountain Diversion Financing Mechanism

Three transmountain diversion projects were studied that would divert Gunnison Basin water from the Upper Taylor River watershed to the South Platte River Basin (Collegiate Range, Union Park and Taylor Park Projects). One project that can only divert economically to the Arkansas River Basin (Modified Central Colorado Project) was also studied.

Two of the projects evaluated, Collegiate Range and Union Park, require the construction of major storage reservoirs in the Study Area and a water conveyance system to the east slope. The Taylor Park Project requires a water conveyance system to the east slope and a relatively minor east slope storage but no new west slope storage facilities. Thus, potential environmental impacts are considered to be greater for the Collegiate Range and Union Park Projects than for the Taylor Park Project.

Since the Collegiate Range Project includes two mainstem reservoirs located in heavily used and relatively sensitive areas, one on the Upper Taylor River above the existing Taylor Park Reservoir and one on the East River near Almont. The proposed Almont site would inundate the existing Roaring Judy fish hatchery which is considered by the CDOW to be unique, and sections of the East and Lower Taylor River. Both of these areas are popular, heavily used recreation corridors. The Collegiate Park project configuration appears to be potentially more environmentally damaging than the Union Park Project which includes one off-stream reservoir located on Lottis Creek, a tributary of the Upper Taylor River. However, it should be noted that the level of the present study only allows a subjective comparison to be made and specific impacts must be studied in future study phases before a quantitative comparison of projects can be made.

All three of the South Platte delivery projects will impact Taylor River flows below Taylor Park dam. At present, Taylor Park Reservoir is operated in a manner to ensure that minimum streamflows below the dam are suitable for the existing high quality fishery that exists in Taylor River. Flow in the river normally exceeds the minimum values by a substantial amount at present. It should be noted that the term "minimum instream flow" when used in the context of a water export project has a different meaning than normal. With a transbasin export project in place, the water exporting entity must maximize the quantity of water exported and will therefore release only the amount of water required to provide the agreed upon downstream flow requirements. The result is that the "minimum instream flow" may become the "normal instream flow" after such a project is constructed. Thus, the establishment of instream flow requirements downstream of a transbasin diversion project requires careful study and consideration.

The Taylor Park Project was evaluated using the hydrologic model to study downstream environmental effects associated with project implementation. For the same level of export, the downstream effects will be similar for each of the South Platte delivery projects. Therefore, the Taylor Park project assuming downstream flow regime II (minimum downstream flows equal to present target minimums); a minimum pool in Taylor Park Reservoir of elevation 9268 ft (23,400 af) and the existence of the three in-basin reservoirs is discussed below as an example of the downstream effects of a transmountain diversion project that exports approximately 42,000 af per year on the average combined with in-basin development. If higher levels of export are considered, the resulting impacts will be greater.

Taylor Park Reservoir has a capacity of 106,200 af and a maximum surface area of 2,033 acres. The reservoir is managed by the Uncompahgre Valley Water Users Association and recreation and fisheries are managed by the USFS and the DOW respectively. Fish species present include rainbow, brown and brook trout, Mackinaw (lake) trout, kokanee salmon, and northern pike. At the present time there is concern that Mysis shrimp, a small fresh water

invertebrate, are competing with the rainbow trout and kokanee salmon and reducing the growth and survival of these species in the lake.

There are approximately 20 miles of the Taylor River between the reservoir and the river's confluence with the East River. Approximately half of this distance is public land, and present recreation use is high. The river's flows are controlled by the reservoir and in recent years the reservoir operations have been modified to improve brown trout spawning conditions. At the present time the river supports a good population of naturally reproduced brown trout that is supplemented with stocking of rainbow trout. Fish growth is slow except in the upper 2 to 4 miles where rapid growth has been observed in recent years as the trout feed on Mysis shrimp discharged from Taylor Park Reservoir.

As modeled under this alternative, average monthly contents of Taylor Park Reservoir would range from approximately 23,000 af to 106,200 af. At the present time there is no minimum pool requirement. Table 16.2 summarizes the reservoirs operation under this export alternative.

TABLE 16.2

Taylor Park Project - Scenario 8

Taylor Park Reservoir Contents
(Start of Month Acre-Feet)

Month	Average Content	Minimum Content	Maximum Content
January	82,975	33,737	104,341
February	79,099	29,433	101,137
March	75,129	25,175	97,979
April	70,969	23,390	95,048
May	68,795	23,309	99,660
June	81,507	29,417	106,200
July	99,547	67,513	106,200
August	99,307	59,779	106,200
September	97,795	54,766	106,200
October	92,577	48,293	106,200
November	89,840	43,996	106,200
December	86,701	38,841	105,445

This reservoir operation results in generally higher reservoir water contents and less fluctuation than seen under Scenario 1 conditions. This would improve recreation conditions at the reservoir and perhaps the fishery. The improved operation is possible because Blue Mesa Reservoir downstream would be used to store and release some of the water now released from Taylor Park for use in the Uncompahgre Project. Figure 15.8 shows the operation of Taylor Park Reservoir under this alternative.

Flows in the Taylor River would be reduced by 42,000 af under this alternative. However, a minimum flow of 75 cfs would be maintained. Table 16.3 summarizes flows below Taylor Park Dam under this alternative.

TABLE 16.3

Taylor Park Project - Scenario 8

Taylor River Flows Below Taylor Park Dam
Average Monthly cfs)

Month	Average Flow	Minimum Flow	Maximum Flow
January	75	75	75
February	75	75	75
March	75	75	75
April	100	100	100
May	170	150	387
June	370	150	897
July	277	150	1158
August	128	100	364
September	106	100	219
October	78	75	128
November	75	75	75
December	75	75	75

This flow regime has not been analyzed by fishery biologists in detail. However optimum flows in the river for brown trout are probably in the range of 150 cfs to 300 cfs. There is a sharp decline in habitat when flows drop below 100 cfs. The table above shows some drops below 100 cfs; however it should be considered that tributary inflows below the dam increase the Taylor River by 40 to 50 cfs in the winter and higher in the summer. Thus the proposed flows should maintain present fishery populations.

Fisherman use could increase as the Taylor River becomes more fishable at lower flows. Recreational rafting would decline or at least become more difficult.

Blue Mesa Reservoir would operate at lower levels than in the No-Action Alternative with the transmountain diversion project and the three in-basin reservoirs in place as shown in Figure 15.11. The results indicate that Blue Mesa Reservoir will operate at levels five feet or more lower than under the No-Action Alternative approximately 50 percent of the time. The effect on Blue Mesa Reservoir will be even greater if higher export levels are contemplated. This may possibly affect recreation and the fishery at Blue Mesa adversely and requires additional detailed study and evaluation. Modifications to the Blue Mesa operating rules may mitigate this effect but this result demonstrates that the potential impacts of transmountain exports from the basin headwaters in combination with in-basin development extends far beyond the immediate area of the diversion point.

16.1.5 Pumped-Storage Project

There have been many potential pumped-storage sites identified in the Gunnison River drainage as discussed in Chapter 15.0. The Needle Point No. 3 project was selected for a brief environmental evaluation to identify typical concerns associated with a pumped-storage project.

The Needle Point No. 3 pumped-storage project utilizes the existing Morrow Point Reservoir as its lower reservoir and would include the construction of an upper reservoir on the north canyon rim with a tunnel connecting the two reservoirs. The power house would be located underground.

Morrow Point Reservoir is narrow and deep with very limited access due to the steep canyon walls that make up most of its shoreline. The area is part of the Curecanti Recreation Area and is managed by the National Park Service. At the upper end of the reservoir, the National Park Service has developed a walk-in recreation access and a tour boat operates from there. Several other trails lead to the reservoir. The primary recreation activity on the reservoir is sightseeing, although fishing for trout and kokanee salmon also occurs.

General environmental concerns that should be addressed with a plan like this are effects of construction on the environment and the effects of daily reservoir fluctuations on recreation, aesthetics, fish and wildlife, and reservoir rim stability.

Morrow Point has minimal daily fluctuations in water level under present conditions but they would be increased by about 10 to 12 feet under a pumped-storage plan. This would adversely affect both recreation use and aesthetics. There is probably very little natural reproduction of fish in the steep sided reservoir at present but the increased fluctuations could impact growth of fish in the reservoir. Fish loss through the pumpback operation may also occur. The upper reservoir and associated access roads and transmission lines would reduce wildlife habitat. The area is used by both mule deer and elk. Additionally, there is considerable sightseeing traffic at present on the existing highway in the area of the proposed upper reservoir which may be impacted by construction of that facility. Increased fluctuation in Morrow Point has the potential to possibly activate existing landslides along the shoreline. All of these factors would require additional study if it is determined that the facility merits additional evaluation.

The magnitude of the potential impacts to existing recreation on and around Morrow Point reservoir suggests that other identified sites should continue to be considered in the future.

16.2 MITIGATION PROPOSALS

16.2.1 General

Mitigation measures are designed to reduce adverse environmental impacts of developments. For example, the effect of inundating big game range can be reduced by improving the carrying capacity of range in the near-by vicinity.

16.2.2 Proposals

Specific mitigation measures for alternatives would be developed in later studies in consultation with government agencies and private organizations. The types of proposals that would be analyzed for different type impacts are listed below:

Impact	Potential Mitigation Measure
Big game range inundation	Acquisition and improvement of nearby ranges
Highway relocation in big game range	Road design, fencing, signing
Human disturbance to wildlife	Seasonal closures, road closures, reservoir zoning
Wetland losses	Creation of new wetlands or improvement of existing wetlands
Inundation of stream fishery	Improved flows downstream, outlet works design,reservoir operation plans, access to other streams
Increased recreation and human activity	Facilities to direct and control traffic, off-road activities, sanitation.

16.3 FUTURE ACTIVITIES

16.3.1 Data Needs

Future work on the project would include site specific studies on existing fish and wildlife resources. Instream flow needs would be better

defined and factors limiting fish and wildlife in specific areas would be determined. The cost effectiveness of fish and wildlife mitigation and enhancement measures would be studied to maximize benefit to these resources. Enhancement features would be designed and management plans and agreements prepared.

Recreation needs and recreation carrying capacity would be more thoroughly studied to optimize proposed recreation developments. Instream flow needs for recreation such as rafting and fishing would be more accurately determined.

Effects of various alternatives on endangered species would be determined in conjunction with the USFWS. The effect of depletions from the Colorado River system on downstream endangered fish species would be determined.

16.3.2 Agency Coordination

Land management agencies such as the USFS and the BLM would take an active role in future studies as would other agencies such as the DOW and local government organizations. The USFWS would prepare reports on the proposals under authority of the Endangered Species Act and the Fish and Wildlife Coordination Act.

16.3.3 National Environmental Policy Act

Alternatives that would involve Federal lands or Federal approvals and permits would be subject to compliance with the National Environmental Policy Act (NEPA). A lead Federal agency and cooperating agencies would be designated.

The NEPA process would begin with an environmental scoping process to help determine significant environmental concerns, discuss alternatives, and determine study needs. Depending on the significance of environmental impacts

of the final proposals, either an environmental assessment or a draft and final environmental impact statement would be required.

17.0 CONCLUSIONS AND RECOMMENDATIONS

17.1 CONCLUSIONS

The Upper Gunnison-Uncompahgre Basin Phase 1 Feasibility Study accomplished the objectives established in the Plan of Study. The key findings are summarized below:

- Although the Study Area has sufficient water on an average annual basis to meet projected demands over the 50-year planning horizon, shortages will exist unless additional development and/or improved management of the existing supply is undertaken to effectively utilize existing water supplies. Non-structural water management and conservation measures as well as structural means were investigated as a way of meeting the projected shortages.

- Non-structural measures related to the municipal and industrial sector were found to have little potential in the context of this basin-wide study because the total consumptive use in this sector is less than two percent of the total consumptive use in the entire Study Area at present. Some of the measures should be considered for implementation at the local level in the future, however. Non-structural measures identified in the agricultural sector were found to be either technically or economically infeasible except for water rights exchanges and/or transfers and possibly drought leasing. The first two measures were used in the identification of potential financing mechanisms. Drought leasing was not used as a component in this study but should be considered in future phases of the study as a potential means of enhancing instream flows.

- Six alternative development plans were identified and evaluated for their ability to meet future water demands and enhancing the existing recreation sector of the local economy. The preferred plan consists of the following: a 20,000 acre-foot multipurpose

reservoir in the Ohio Creek Sub-basin; a 25,000 acre-foot multipurpose storage reservoir in the Tomichi Creek Subbasin; and ten recreation enhancement components. The total capital cost of this plan is approximately $55,500,000 (January 1989 price level). This plan can be developed in stages and a financial analysis was performed on a Phase 1 concept which includes the Tomichi Creek storage reservoir and the ten recreation components. The total capital cost of Phase I is approximately $32,000,000. The analysis showed that the total annual cost associated with Phase 1 would be about $1,250,000. The direct project annual income would only be about $140,000 but the project would result in significant indirect economic benefits to the Study Area through increased tourism (estimated to be $4,450,000 annually). Construction of Phase I will also result in year-round increased streamflow below the reservoir which would result in an enhanced stream fishery.

- The study effort indicates that numerous potential pumped-storage sites exist in the Study Area and that several of these sites appear to be economically attractive.

- Out-of-basin diversion from the headwaters of the Taylor River was also investigated. The hydrologic yield of such projects depends on many technical and institutional considerations including, but not limited to, the water right used for the export and the instream flow requirements in the Taylor River drainage. A potential export project entails many conflicts with the holders of other water rights and with the operators of existing facilities. Using the Taylor Park Project and a senior water right to support the diversion, the average annual yield would range from about 24,000 af to about 60,000 af depending on Taylor River instream flow requirements. The same project using new water rights would have an average annual yield ranging from about 18,000 af to about 24,000 af, again, depending on Taylor River instream flow requirements. If the existing privately-held instream flow water rights are enforced

and junior water rights are used in conjunction with the export, the average annual yield would be about 7,200 af. The export yield could be enhanced for any of the situations discussed above by pumping water from Blue Mesa Reservoir. A project arrangement where an additional 58,000 af per year would be pumped from Blue Mesa Reservoir was evaluated and resulted in 25 percent cost savings per af of yield. The potential environmental effects of transmountain diversions on instream flows and water levels at Blue Mesa Reservoir become significant above certain levels of export. These effects may adversely affect the recreation-based economy of the Study Area.

17.2 RECOMMENDATIONS

The preferred in-basin development plan consisting of storage reservoirs and recreation components provides a relatively wide range of benefits; however, the project is not financially feasible on its own. The indirect benefits generated by the project indicate that further evaluation of the project may be warranted. It is recommended that the following be included in future study phases: refinement of project costs and benefits; perform a more detailed assessment of the possibility of raising income to pay project debt service by other means than through direct project income; and perform a refined financial analysis.

Based on the results of this preliminary level study, it appears that financially feasible pumped-storage sites may exist in the Study Area. This potential should be studied in more detail in the future to identify a preferred site and to quantify the potential economic benefits associated with such a development.

It is recommended that further study of potential transmountain diversion projects be undertaken in order to: define the amount of water available for diversion under various assumptions; define the downstream economic and environmental impacts of diversion; prepare a detailed comparison of

alternative projects; and prepare a detailed cost estimate and refined financial analysis of the potential alternative.

GLOSSARY AND ABBREVIATIONS

A

absolute water right - A water right that has been perfected and placed to beneficial use.

abutment - The Support at the end of a dam, arch or bridge.

acre - A measure of area; equivalent to 43,560 square feet.

acre-foot (af) - The volume of water, equal to the quantity required to cover an acre of land to a depth of 1 foot, equivalent to 43,560 cubic feet or about 326,000 gallons.

acre-feet per year (af/yr) - The flow rate of water equal to one acre-foot per year (equivalent to 0.00138 cubic feet per second for one year).

adjudication - A judicial proceeding in which a priority is assigned to an appropriation and a decree issued defining the water right.

alluvium - Clay, silt, sand, gravel, or material deposited by running water.

appropriation - The volume or flow of water that is legally allocated to an individual, municipality, corporation, or government entity for an identified beneficial use.

aquifer - A geologic formation that contains sufficient saturated permeable material to yield water to wells and springs.

arable land - Land that can be farmed economically.

average flow - The arithmetic mean of flow rates over a period of time, usually one year.

B

basalt - A dark, fine-grained extrusive rock composed primarily of feldspar and pyrozene.

baseload capacity - The minimum load over a period of time.

baseload unit - A generating unit which is normally operated to take all or part of the baseload of a system and which, consequently, operates essentially at a constant output.

basin - The drainage or catchment area of a stream or lake.

basin rank - A number used in Colorado by the State Engineer in the tabulation of decreed water rights to indicate the relative standing of a decreed right with respect to all other decreed rights within a water division.

bedrock - Any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

beneficial use - The use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish, without waste, the purpose for which the diversion is lawfully made including water for recreational purposes, including fishery or wildlife.

benefits (economic) - The increase in economic value produced by the addition of a project, typically represented as a time stream of value produced by the generation of consumable resources.

C

calibration - Usually a trial and error procedure of adjusting simulation model coefficients such that results from the model provide a reflection of the actual system.

call - The placing of a request by a senior priority to the Water Commissioner to shut down junior priorities so that the senior is able to divert its full entitlement.

capacity - The power output or load that a turbine-generator, station, or system is capable of producing.

capacity, peaking - Generating units or stations which are normally utilized to serve that portion of load which is above base load.

capacity value - That part of the market value of electric power that is assigned to dependable capacity.

capital cost - The amount of money paid for project construction and interest during construction.

compact - A contract between states of the Union, entered into with the consent of the National Government, and in water, defining the relative rights of two or more states on an interstate stream to use the waters of that stream.

conditional decree - A decree of the court awarding a priority date of appropriation to use water even though actual taking and use of the water is delayed until a future time, usually until a project is constructed.

construction cost - The amount paid for building project facilities plus appropriate contingencies, as well as engineering, legal, and administrative expenses.

consumptive use - The amount of water consumed during use of the water and no longer available to the stream system. For irrigation, consumptive use is water used by crops in transpiration and building of plant tissue.

contingency factor - An additional amount added to cost estimates in recognition of unknown factors that could result in higher actual costs.

conveyance loss - The loss of water from a conduit or open channel due to leakage, seepage, evaporation or evapotranspiration.

correlation - The process of establishing a relation between a variable and other related variables.

crest - The top line or peak of a dam or hill.

Cretaceous Period - The third and latest of the periods included in the Mesozoic Era, approximately from 65 to 135 million years ago.

crop irrigation requirement - The amount of water required at the farm field level to supplement natural precipitation in satisfying the crops consumptive use.

cubic feet per second (cfs) - A measure of a fluid flow rate at one cubic foot of fluid every second (equivalent to 724 acre-feet per year or 449 gallons per minute).

cultural resource - A building, site, district, structure, or object significant in history, architecture, archaeology, culture or science.

D

dead storage - The volume in a reservoir below the lowest controllable outlet and therefore the volume which cannot be released by gravity flow.

debt service - Principal and interest payments necessary to retire the debt incurred in financing a project.

decree - An official document issued by the Court defining the priority, amount, use, and location of a water right or plan of augmentation. When issued, the decree serves as a mandate to the State Engineer to administer the water rights involved within the statewide system.

deep percolation - The drainage of soil water by gravity below the maximum effective depth of the root zone and is therefore lost to possible use by the plant.

delivery efficiency - The volume of water delivered to the farm divided by the volume diverted from the source.

depletion - Net rate or quantity of water taken from a stream or ground water aquifer and consumed by beneficial and non-beneficial uses. For irrigation or municipal uses, the depletion is the headgate or well-head diversion less return flow to the same stream or ground water aquifer.

developed recreation site - Land that has been substantially modified by construction of campgrounds, ski areas, etc.

direct diversion - The diversion of water from a natural flowing stream.

direct flow right - A right defined in terms of discharge and which must be put to use more or less promptly following diversion from the source.

discharge, or rate of flow - The volume of water passing a particular point in a unit of time. Units of discharge commonly used include cubic feet per second (cfs) and gallons per minute (gpm).

ditch (or canal) - A trench cut into the surface of the ground to transport water from a stream or reservoir to a point of use away from the source.

diversion records - Record of the daily flow in cubic feet per second for a ditch or other diversion structure. Compiled by the District Water Commissioner, ditch rider or other water official, diversion records are generally on file and available for review at the State Engineer's Office.

drainage area - The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide. It is expressed in acres, square miles or other units of area.

drawdown - The decrease in elevation of a lake, reservoir, or aquifer due to a release or discharge from the lake or reservoir or by pumping from the aquifer.

E

Eastern Slope - That portion of Colorado lying east of the Continental Divide.

effective precipitation - The amount of rain that falls during the growing season and is available for growth of crops. Effective precipitation is a portion of the total precipitation that falls during the growing season and is a function of the type of soil, the time period in which each rain falls, and its intensity. Thus, effective precipitation usually is less than precipitation measured at a given point.

endangered species - Life forms found on the U.S. Department of the Interior's list and published in the Federal Register. Their presence on the list implies their continued existence as a species is questionable.

energy - The capacity for performing work. The electrical energy term generally used is kilowatt-hours and represents power (kilowatts) operating for some time period (hours).

enlargement (water rights) - A subsequent right awarded to a ditch or structure enlarging the amount granted originally. More than one enlargement may be awarded to a ditch or structure and each enlargement will have a priority related to the date it was appropriated and applied to beneficial use. Enlargements may be absolute or conditional.

environment - All the conditions, circumstances, and influences surrounding and affecting the development of an organism or group of organisms.

evaporation - The physical process by which a liquid or solid is transformed to the gaseous state which in this study is meant the change of water from liquid to gas.

evapotranspiration - The combined processes by which water is transferred from the earth's surface to the atmosphere; evaporation of liquid or solid water plus transpiration from plants (see consumptive use).

exchange - A formal or informal agreement between owners of water rights to allow flexibility in the use of water. An example would be releasing reservoir storage water to a calling ditch, rather than decreasing the upstream diversion to storage.

F

farm headgate irrigation efficiency - The volume of water consumed by crops divided by the volume of water delivered to the farm.

fault - A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.

feasibility study - An investigation performed to formulate a project and definitively assess its desirability for implementation.

Federal Energy Regulatory Commission (FERC) - An agency in the Department of Energy which licenses non-Federal hydropower projects and regulates interstate transfer of electric energy.

firm water supply (or yield) - An assured minimum supply of water (or yield) under the most adverse water year supply conditions.

firm energy - The energy generation ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified for a particular system load.

flood - Any relatively high streamflow which overtops the natural or artificial banks of a stream.

freeboard - Represents the vertical distance between the maximum elevation reached in routing of the spillway design flood and the top of the dam.

G

gaging station - A particular site on a stream, canal, lake or reservoir where systematic observations of water level and/or velocity of flowing water are made.

generator - A machine that converts mechanical energy into electrical energy.

glaciation - Alteration of the earth's solid surface through erosion and deposition by glacial ice.

gneiss - A course-grained rock in which bands rich in granular minerals alternate with bands in which schistose minerals predominate.

granite - Quartz-bearing igneous rock characterized by granular texture and having feldspar as the chief mineral.

gross head - The gross difference in elevation between the headwater surface above and the tailwater surface below a hydroelectric power plant, under specified conditions.

ground water - For administrative purposes, ground water is usually defined as any water not visible on the surface of the ground under natural conditions.

ground water recharge - Inflow to a ground water reservoir.

ground water reservoir - An aquifer or aquifer system in which ground water is stored. The water may be placed in the aquifer by either artificial or natural means.

grout curtain - A water barrier in a dam foundation formed by inserting chemicals or cement through drilled holes.

H

headgate - A physical structure on a stream through which water is diverted into a ditch.

head losses - Reductions to the gross difference in elevation between water surfaces upstream and downstream from a hydroelectric power plant due to friction of the flow of water through a penstock or conduit and changes in direction or velocity of the flow.

headwaters - Sources of water in a stream.

headworks - Structure at the head of a channel or conduit for diverting water into the channel.

historic use - The documented diversion and use of water by a water right holder over a period of years.

hydroelectric plant or hydropower plant - An electric power plant in which the turbine-generators are driven by falling water.

hydrology - The science dealing with water on the land, its properties, laws, and geographic distribution.

I

igneous - Rocks formed by solidification from a molten or partially molten state.

impervious - An adjective describing a material through which water either cannot pass or passes with great difficulty.

infiltration - Water moving into the ground from a surface supply such as precipitation or irrigation.

installed capacity - The total of the capacities shown on the nameplate of the generating units in a power plant.

instream flows - A prescribed level(s) of streamflow.

inundate - To flood or cover with water.

investment cost - The amount required for payment of the capital cost, establishing a debt service reserve fund, and financing expenses.

irrigable land - Arable land for which a water supply is available.

irrigation - The application of water to crops, lawns, and gardens by artificial means to supplement natural precipitation. Water can be applied by spreading over the ground, by sprinkling, or dripping.

irrigation system efficiency - The ratio of the volume of water consumed by crops divided by the volume of water diverted from the source.

irrigation return flow - Applied water which is not consumptively used and returns to a surface water or ground water supply. In water rights litigation, the definition may be restricted to measurable water returning to the stream from which it was derived.

irrigation water requirement - The quantity of water, exclusive of effective precipitation, that is required for various beneficial uses.

K

kilowatt (kW) - One thousand watts.

kilowatt-hour (kWh) - The amount of electric energy equal to one kilowatt over a period of one hour. It is equivalent to 3413 btu of heat energy.

L

lateral - A minor ditch headgating off the main ditch used to divert water onto the land. A ditch may have many laterals, depending on the amount of acreage irrigated, the slope of the land, and the rate of seepage losses.

load - The amount of power needed to be delivered at a given point in an electric system.

load factor - The ratio of the average load during a designated period to the peak or maximum load occurring in that period.

loss - The difference between the amount of water that is actually placed on the land and the amount of water that was physically diverted to the headgate. Losses usually are from seepage and evaporation.

M

mean annual flow - The average or yearly flow of a stream.

megawatt (MW) - One thousand kilowatts.

megawatt-hour (MWh) - One thousand kilowatt-hours.

metamorphic rock - Includes all those rocks which have formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment.

mitigate - To lessen the severity.

N

net benefits - The results of subtracting total costs from total benefits.

net head - The adjusted gross head on a power plant, accounting for reductions due to head losses.

non-consumptive use - A use of water that does not reduce the supply, such as for hunting, fishing, boating, water-skiing, and swimming.

non-tributary ground water - Water that is not part of (connected to) a natural stream as established through geologic and hydrologic facts. The factual determination of "non-tributary" usually involves the length of time the impact of withdrawal would take to reach the stream and the amount of impact relative to the total volume of surface flow impacted.

O

out-of-priority storage option - The ability to store water before one has the right according to his court decree to do so.

outcrops - Exposure of geologic formations on the land surface.

outlet works - A gated or valved conduit at a dam and reservoir used to regulate discharges from storage.

overburden - Material of any nature, consolidated or unconsolidated, that overlies a rock unit of interest.

P

Paleozoic - One of the eras of geologic time. Approximately from 225 to 570 million years ago.

pasture - Land that is currently improved for grazing by irrigation or other means.

peaking capacity - That part of a system's generating capacity which is operating during the hours of highest power demand within the system.

peak load - The maximum load in a stated period of time.

permeability - A term used to describe the ability of water or other liquid to move through a porous media.

permeable material - Material which allows water to pass through easily.

phreatophyte - A water-loving plant which consumes a substantial amount of water without corresponding benefits to mankind, such as cottonwood trees or salt cedars.

plant factor - Ratio of the average load to the installed capacity of a hydroelectric plant, usually expressed as an annual percentage.

plateau - A relatively elevated area of comparatively flat land which is commonly limited on at least one side by an abrupt descent to lower land.

Pleistocene - The earlier of the two epochs in the Quarternary Period, approximately from 0.1 to 2 million years ago.

power (electric) - The rate of generation or use of electric energy, usually measured in kilowatts.

Precambrian - All rocks formed before the Cambrian Period, approximately from 570 million years ago to the formation of the earth.

precipitation - The discharge of water, in liquid or solid state, out of the atmosphere.

prefeasibility study - An investigation performed in advance of a full feasibility level study to evaluate available resources and to define alternative resource development options in order to define which options warrant further study.

priority - The relative seniority of a water right as determined by its adjudication date and appropriation date. In some cases, other factors are also involved in determining priority. The priority of a water right determines its ability to divert in relation to other rights in periods of limited supply.

probable maximum flood (PMF) - The estimated flood that would result if all factors that contribute to a flood were to reach the most critical combination of values that could occur simultaneously.

R

recreation user day - One visitor spending all or part of a day.

recreation visitor days - Twelve visitor hours, which may be aggregated continuously, intermittently or simultaneously by one or more persons.

reservoir - A pond, lake, or basin, either natural or artificial, used for the storage, regulation, and control of water.

return flow - Unconsumed water which returns to its source or some other water body after its diversion as surface water or its extraction from the ground.

reuse - Subsequent use of imported water, by the importer, for the same purposes as the original use. An example would be the treatment of sewage water to result in potable water to be recycled into the raw water system.

revenue bond - Project funding, repayment for which is strictly dependent on the income from the project to meet the interest and principal payments.

roller compacted concrete (RCC) dam - A dam consisting essentially of an inner or enclosed low cement content concrete mixture which is placed and compacted using earth moving equipment.

run-of-the-river (plant/hydroelectric generation) - A power plant that uses natural flows or flows released for other purposes to generate power.

S

sandstone - A cemented or otherwise compacted detrital sediment composed predominantly of sand-sized quartz grains.

schist - A medium or coarse-grained metamorphic rock with subparallel orientation of the micaceous minerals which dominate its composition.

sediment - Solid material, both mineral and organic, that in suspension has been transported from its site of origin by air, water, or ice.

sedimentary rocks - Rocks formed by the accumulation and compaction of sediment in water or from air.

sedimentation - The process of deposition of suspended matter carried by water. It is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material.

sediment storage - The volume of a reservoir set aside to store incoming sediments that are deposited in the reservoir over the useful life of the project.

seepage - (1) The slow movement of water through small cracks, pores, interstices, etc., of a material into or out of a body of surface or subsurface water. (2) The loss of water by infiltration into the soil from a canal, reservoir, or other body of water, or from a field.

seismic - Pertaining to an earthquake or earth vibration.

seismicity - The phenomenon of earth movements or seismic activity.

shale - A laminated sediment in which the constituent particles are predominantly of the clay grade.

shear zone - A zone in which shearing has occurred on a large scale so that the rock is crushed and brecciated.

siltstone - Shale comprised of silt-sized grains.

spillway - Overflow channel of a dam provided to safely pass flood flows which cannot be stored in the reservoir without overtopping the dam.

storable flow - The portion of river inflow to a reservoir legally available for storage in the reservoir after considering all senior water rights and diversions both upstream and downstream.

storage decree - A decree of the court allowing the storage of water, usually in a reservoir.

storage right - A water right defined in terms of the volume of the water which may be diverted from the flow of the stream and stored in a reservoir or lake to be released and used at a later time either within the same year or a subsequent year.

stream - A general term for a body of flowing water. In hydrology the term is generally applied to the water flowing in a natural channel as distinct from a canal.

supplemental irrigation water - Additional water applied to irrigate crops over and above that historically or normally used, which could be beneficially used to increase the crop yield or to support growing higher value crops.

switchyard - An area, usually fenced, containing equipment for routing the flow of electrical power.

T

tailrace - A channel for conveying discharged water from a hydroelectric power plant.

terrace - A relatively flat, horizontal, or gently inclined surface, sometimes long and narrow, which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.

tertiary - The earlier of two geologic periods within the Cenezoic Era, approximately from two to 65 million years ago.

thermal plant - A generating plant which uses heat to produce electricity. Such plants may burn coal, gas, oil, or use nuclear energy to produce thermal energy.

topographic - Of, relating to, or concerned with the configuration of the earth's surface, including its relief and the position of its natural and man-made features.

topography - The physical features of a district or region, especially the relief and contour of the land.

total consumptive use - The amount of water, regardless of its source, used by a beneficial use. It is the amount of water that is physically removed from the stream's system and is not available for other users on the stream.

trans-basin diversion - The removal of the water of a natural stream from its natural basin into the natural basin of another stream.

transfer - The process of moving a water right originally decreed to one place, to another place, by court decree. A transferred water right generally retains its priority in the stream system and may or may not retain its right to divert its entire decreed amount.

transmission - The act or process of transporting electric energy in bulk.

transmission line - A facility for transmitting electrical energy at high voltage from one point to another point. Transmission line voltages are normally 15 kV or larger.

transmountain - The crossing or extending over or through a mountain.

tributary - Any stream which contributes water to another stream.

tributary ground water - Seepage, underflow, and percolating water that will eventually become part of the natural stream. A natural stream's waters include water in the unconsolidated alluvial aquifer of sand, gravel and other sedimentary materials, and all other waters hydraulically connected thereto, which can influence the rate or direction of movement of the water in that alluvial aquifer or natural stream. In Colorado, all ground water is presumed to be tributary unless proved otherwise.

turbine - The part of a generating unit which is spun by the force of water or steam to drive an electric generator. The turbine usually consists of a series of curved vanes or blades on a central spindle.

V

virgin flow - The rate of water movement past a specified point on a natural stream from a drainage area for which there have been no effects caused by stream diversion, storage, import, export, return flow or change in consumptive use caused by man-controlled modifications to land use.

W

water right - A right to use, in accordance with its priority, a certain portion of the waters of the state by reason of the appropriation of the same.

water level - The height of water in a reservoir, well, or aquifer.

watershed - The whole region or area contributing to the water supply of a river or lake.

water year - The 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes nine of the 12 months. Thus, the year ending September 30, 1959, is the "1959 water year."

water yield (or yield) - The quantity of water expressed either as a continuous rate of flow (i.e., cubic feet per second) or as a volume per unit of time (i.e., acre-feet per year), which can be collected for a given use or uses from surface or ground water sources in a watershed. The yield may vary

with the use proposed, with the plan of development, and also with economic considerations.

weathering - The group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

Western Slope - That portion of Colorado lying west of the Continental Divide.

wilderness - Under the 1964 Wilderness Act, wilderness is undeveloped Federal land retaining its primeval character and influence without permanent improvements or human habitation. It is protected and managed so as to preserve its natural conditions which: 1) generally appear to have been affected primarily by the forces of nature with the imprint of man's activity substantially unnoticeable, 2) has outstanding opportunities for solitude or a primitive and confirmed type of recreation, 3) has at least 5000 acres or is of sufficient size to make practical its preservation, enjoyment, and use in an unimpaired condition, and 4) may contain features of scientific, educational, scenic, or historical value as well as ecologic and geologic interest.

ABBREVIATIONS AND ACRONYMS

AC	Advisory Committee
af	acre-feet
Authority	Colorado Water Resources and Power Development Authority
BLM	Bureau of Land Management
BPWCD	Bostwick Park Water Conservancy District
CBMR	Crested Butte Mountain Resort
CDPOR	Colorado Division of Parks and Outdoor Recreation
CDOW	Colorado Division of Wildlife
cfs	cubic feet per second
CRSP	Colorado River Storage Project
CRWCD	Colorado River Water Conservancy District
CWCB	Colorado Water Conservation Board
cy	cubic yard
EPA	Environmental Protection Agency
El.	Elevation
ft	Feet
FERC	Federal Energy Regulatory Commission
gpd	gallons per day
gpm	gallons per minute
GWh	gigawatt hours, equivalent to 1000 MWh
kV	kilovolt
kW	kilowatts, equivalent to 1000 watts
kWh	kilowatt-hour
M&I	Municipal and Industrial
mgd	million gallons per day
MSL	mean sea level
MW	megawatts, equivalent to 1,000,000 watts(capacity term)
MWh	megawatt hours (energy term)
NEPA	National Environmental Policy Act
NPS	National Park Service
OM&R	Operation, Maintenance, and Replacement
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
POS	Plan of Study
RUD	Recreational User Day
RVD	Recreational Visitor Day
RMBL	Rocky Mountain Biological Laboratory
SEO	State Engineers Office
SWA	State Wildlife Area
sq. mi.	square miles
TSC	Technical Steering Committee
UGRWCD	Upper Gunnison River Water Conservancy District
USBR	United States Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UVWUA	Uncompahgre Valley Water Users Association
WAPA	Western Area Power Administration
yr	year